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NOTICES

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PLUM-MOSAIC, A VIRUS DISEASE OF PLUMS, PEACHES AND APRICOTS IN NEW ZEALAND

By E. E. CHAMBERLAIN, Plant Diseases Division, J. D. ATKINSON, Fruit Research Station, and J. A. HUNTER, Plant Diseases Division, Department of Scientific and Industrial Research, Auckland

(*Received for publication, 2 May 1950*)

Summary

Plum-mosaic, a virus disease of stone fruits, was first observed in New Zealand during the spring of 1946.

Since its discovery it has been found throughout the Dominion, incidence occasionally being high in cherry plum and a few European and Japanese plum varieties.

The disease produces a wide range of symptoms on different varieties and species or even on the same variety. Symptoms which occur on leaves consist of yellow to creamy-white veinbanding, chlorotic lines which sometimes form oak-leaf-like patterns, chlorotic spotting, interveinal chlorosis, or mosaic mottling.

It has been found occurring naturally on a number of European (*Prunus domestica*) and Japanese (*P. salicina*) plum varieties, Myrobalan (*P. cerasifera*), *P. insititia*, peach (*P. persica*), apricot (*P. armeniaca*) and Mahaleb cherry stock (*P. mahaleb*). It has been transmitted experimentally by budding to nectarine (*P. persica*), almond (*P. communis*) and sour cherry stock (*P. cerasus*).

The disease is readily transmitted by budding.

Observations and preliminary experiments indicate that on cherry plum stocks this disease has an adverse effect on survival of buds of some plum and apricot varieties.

Spread has not been observed other than by budding or the use of cutting wood taken from infected trees.

The virus appears to be closely related to, if not identical with, a virus of stone fruits occurring in the United States of America.

Results of experiments on hot water treatment of infected cherry-plum cuttings indicate that the thermal death point of the virus is at least as high as that of the cuttings.

Control measures suggested consist of selecting cuttings for raising stocks from disease-free trees, rogueing infected stocks from nursery beds and use of budwood from healthy trees.

INTRODUCTION

THE presence of a virus disease of stone fruits in New Zealand was first suspected when virus-like symptoms were observed in the spring of 1946 on cherry-plum stocks growing in a Manawatu nursery. Buds

from diseased cherry plums were worked to trees of several plum varieties during December of that year, and the presence of a virus was confirmed by the appearance of symptoms on the new foliage of the budded trees in the following spring. This disease, which has become known in New Zealand as plum-mosaic, has since been observed on plums throughout the Dominion. It has also been found on peaches and apricots.

HOST AND VARIETAL RANGE OF PLUM-MOSAIC

Natural host range:

Plum-mosaic has been found occurring naturally on the following plum, peach and apricot varieties:—

Cherry Plum or Myrobalan (*Prunus crasifera* Ehrh.), Cherry Plum.

European Plum (*P. domestica* L.): Blue Diamond, Climax, Coe's Golden Drop, Evan's Early, Grand Duke, Greengage, Kirk, Monarch, Pershore, Washington, and Yellow Magnum Bonum.

Prunus insititia L.: Common Mussel.

Japanese Plum (*P. salicina* Lindl.), Alpha, Billington's Early, Burbank, Doris, George Wilson, June Blood, October Purple, Purple King, Santa Rosa, Satsuma, Sharpe's Early, Shiro, Vailes, Victory, and Wright's Purple.

Unknown species: Morrison's Plum Stock, European Type Plum Stock.

Peach (*P. persica* Sieb. and Zucc.): Carmen, Golden Queen, Kahuranaki, Royal George, Sneed, and Wiggins.

Apricot (*P. armeniaca* L.): Dundonald, Moorpark, Newcastle, and Roxburgh Red.

Mahaleb cherry stock (*P. mahaleb* L.).

Experimental host range:

Plum-mosaic has been transmitted by budding to the following additional hosts:—

Myrobalan: Pissardi.

European Plum: President.

P. insititia: Black Damas.

Japanese Plum: Black Doris, Hale, Wilson's Early Seedlings.

Peach: Golden Queen Seedlings.

Nectarine (*P. persica*): Seedlings.

Almond (*P. communis* Fritsch.): Monavale.

Sour Cherry Stock (*P. cerasus* L.).

INCIDENCE OF PLUM-MOSAIC

Plum-mosaic occurs throughout New Zealand, having been found in all the main stone fruit areas and on isolated trees in several other localities. On plums, except in the case of a few varieties, incidence is usually not high in established orchards. However, the disease is very common on Santa Rosa plums and in Hawke's Bay it was found to occur in all plantings inspected, infection occurring on more than 95 per cent of the 318 trees examined. Also, in one block of 40 mature Santa Rosa

trees in a Nelson orchard over half were infected, while an incidence of 80 to 100 per cent was observed in several small plantings of this variety in Central Otago. In Hawke's Bay plum-mosaic also has a high incidence on Grand Duke, approximately 80 per cent of 160 trees inspected being infected. The disease appears to be common on cherry plum as in one hedge of 39 trees in the Auckland area 32 trees showed symptoms, and in another in the Manawatu district 14 out of 40 trees were infected. In one nursery a line of several hundred cherry plum stocks raised from cuttings showed over 30 per cent infection. A line of Common Mussel

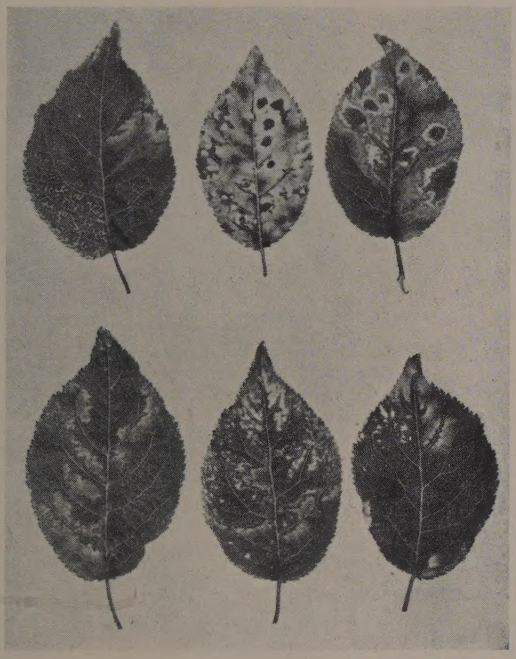


Photo by R. I. Hughes.

FIG. 1.—Range of symptoms produced by plum-mosaic on leaves of cherry plum. All leaves taken from one tree. (X $\frac{2}{3}$).

stocks being grown in Central Otago for experimental purposes showed infection in 27 out of 31 trees. An incidence of over 50 per cent has also been observed in a line of more than 100 young Monarch plum trees.

In apricots the disease has not been observed in more than a few trees in any one orchard. It has been found occasionally on young trees in nurseries.

Natural infection of peaches has been observed in Hawke's Bay where the disease is widely spread although incidence is usually low, and on a single tree in Central Otago.

The disease has also been observed on a Mahaleb cherry stock in a Central Otago orchard.

SYMPTOMS

Observations indicate that on the hosts studied symptoms of plum-mosaic are confined to the foliage. These symptoms, which are extremely variable, consist of light green, yellow or creamy white patterns on leaves. The patterns most commonly encountered are:—

Vein-banding: Light coloured bands adjacent to veins. Bands may be quite narrow and produce a network pattern (Figs. 2d, 2e), or comparatively broad when a large proportion of the leaf is chlorotic (Fig. 2a). This pattern may occur over the whole leaf surface or be confined to one half or merely portion of a leaf (Fig. 2e).

Oak-leaf: A pattern of light coloured lines which often assume the shape of an irregular oak-leaf. Lines may be narrow and clearly defined (Figs. 2b, 3e) or broad and sometimes ill-defined (Figs. 4g, 5c). Especially on peaches, nectarines, and almonds, the chlorotic lines forming the oak-leaf pattern sometimes tend to feather out along the secondary veins (Fig. 6e).

Chevron pattern: On apricots chlorotic lines sometimes appear as chevrons, joined in series, extending horizontally across the leaves (Fig. 5a).

Chlorotic spotting: Light green, yellow or creamy-white spots on leaves. Spots may be few (Fig. 5g) or numerous (Figs. 3g, 3h), and may be scattered evenly over the surface (Fig. 3d), grouped together on portion of the leaf to form large chlorotic areas (Fig. 3i), or arranged in a pattern (Fig. 5f).

Interveinal chlorosis: Large chlorotic areas between secondary veins (Fig. 4a).

Ring spotting: Spots consisting of rings of chlorotic tissue. Spots may be small (Fig. 2c) or large (Figs. 1, 6h) and formed by narrow (Fig. 2c) or broad bands (Fig. 6h). Occasionally the spots consist of two concentric rings (Fig. 2f).

Mosaic mottling: A mottling produced by light and dark green areas. Areas may be bounded by more or less definite margins (Figs. 6b, 6c), or margins may be diffuse (Figs. 3a, 4f).

Details of Symptoms on Known Hosts in New Zealand:

In the following list are given brief descriptions of symptoms which have been observed on either naturally or experimentally infected trees.

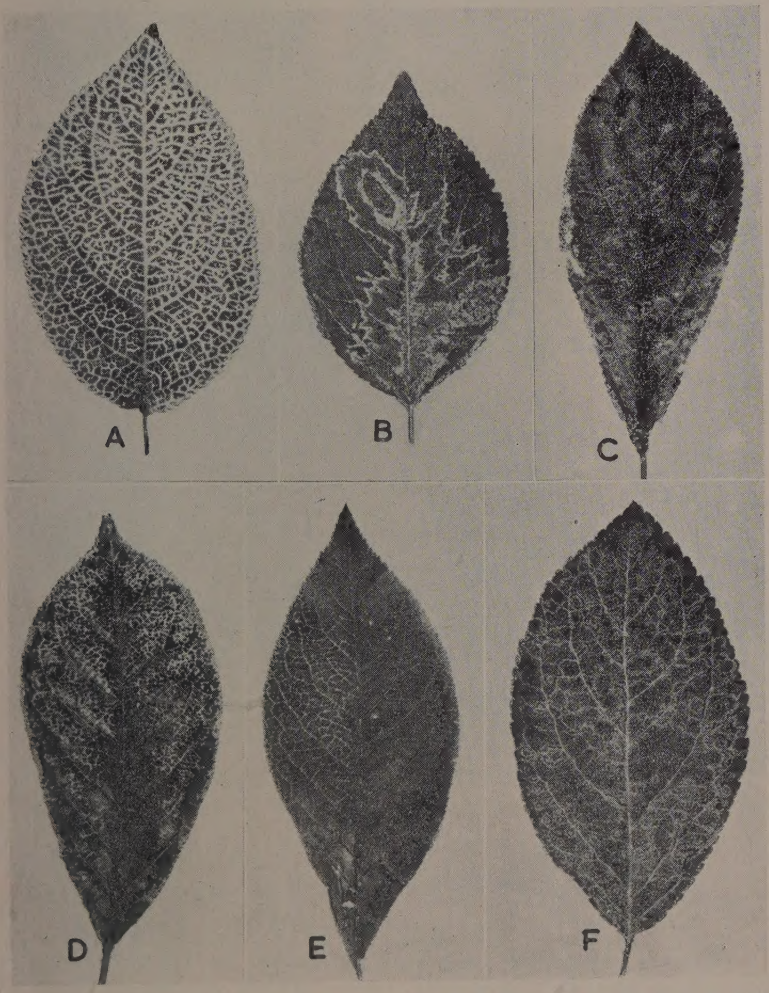
Symptoms given for each variety are the only ones which have been observed but it is probable that in most cases a wider range of symptoms would have been recorded had infected trees been studied under a greater range of growing conditions.

On some varieties including Cherry Plum and many of the Japanese plum varieties, symptoms occur on a high percentage of leaves while in others, including apricots and most European plum varieties, it is common for symptoms to be present on only a few leaves of infected trees.

Effect of Environment on Symptoms:

Symptoms are most pronounced on leaves produced during cool periods and are often absent from foliage formed during the hot summer months. Thus it is not uncommon to find symptoms on leaves formed during the spring at the base of shoots, and on those at the tips pro-

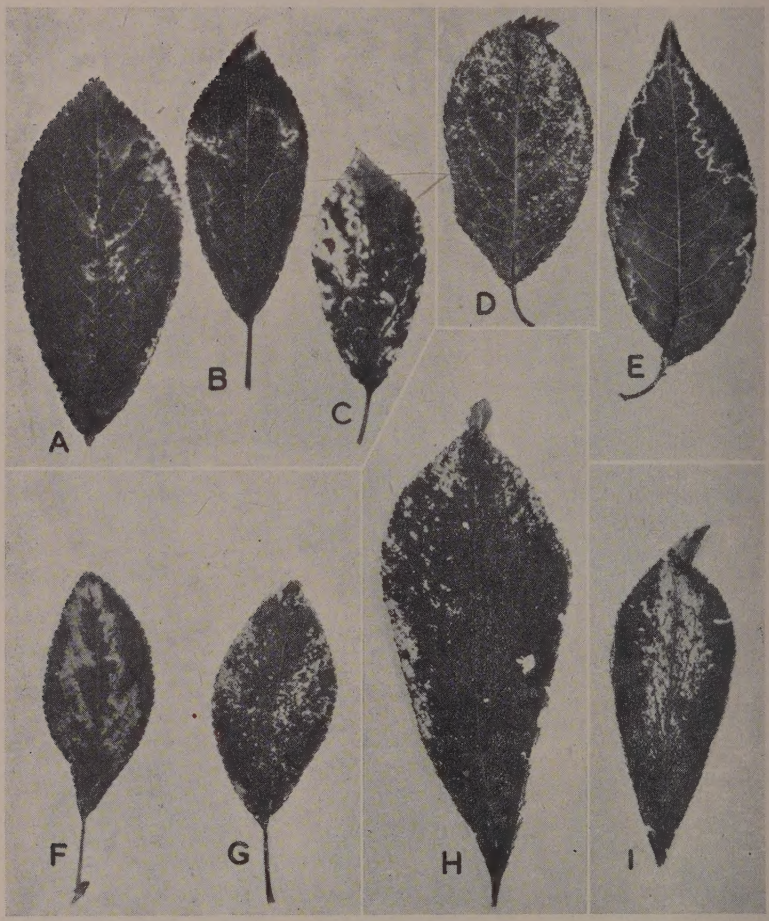
duced during the autumn while the intermediate leaves remain free. On any given tree, symptoms vary not only in intensity but also in pattern type from season to season so that an infected tree which shows only oak-leaf pattern in the early spring may develop vein-banding later in the year.



Photos (a) and (b) by L. H. Wright. (d) and (e) by P. R. Fry. (c) and (f) by R. I. Hughes.

FIG. 2.—Symptoms produced by plum-mosaic on leaves of different plum varieties.

(a) Vein-banding on cherry plum (X $\frac{4}{5}$). (b) Oak-leaf on cherry plum (X $\frac{4}{5}$). (c) Chlorotic ring-spotting on Black Doris (X $\frac{4}{5}$). (d) and (e) Vein-banding on Purple King X $\frac{3}{5}$). (f) Ring-spotting on European type plum stock (X $\frac{7}{8}$).

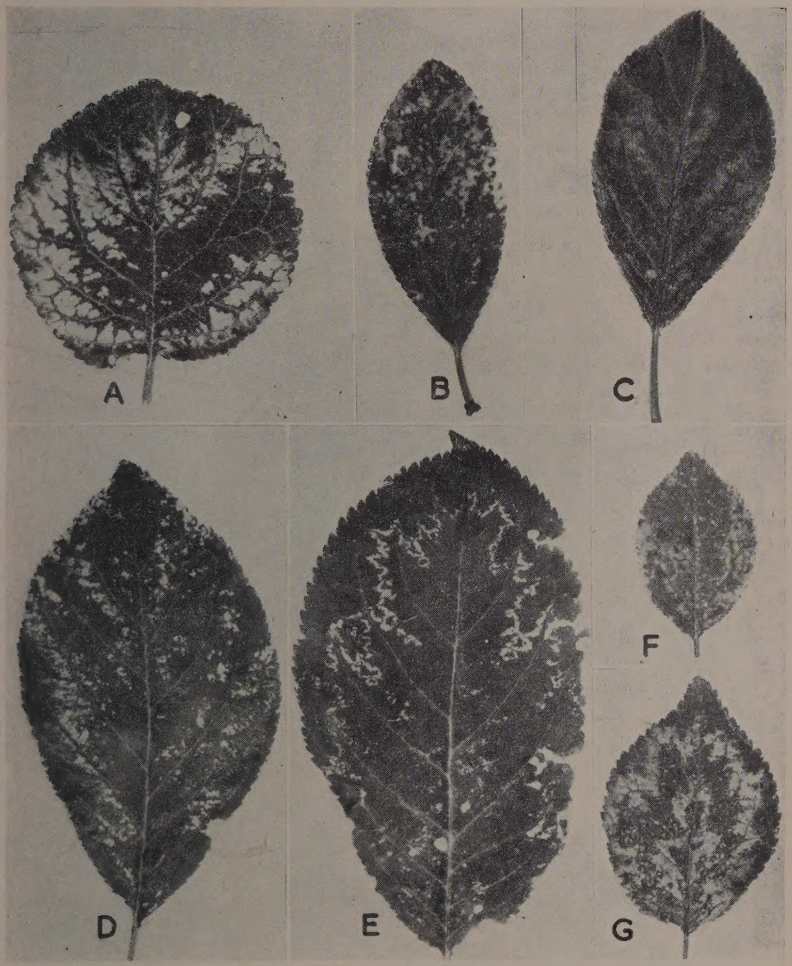


Photos (a), (b) (c), (h) and (i) by R. I. Hughes. (d), (e), (f) and (g) by S. A. Rumsey.

FIG. 3.—Symptoms of plum-mosaic on leaves of different plum varieties. (a), (b) and (c) Oak-leaf and mosaic mottling on Hale (X $\frac{4}{5}$). (d) Chlorotic spotting on Morrison's stock (X $\frac{3}{4}$). (e) Oak-leaf on Morrison's Stock (X $\frac{3}{4}$). (f) Oak-leaf on Evan's Early (X $\frac{3}{4}$). (g) Chlorotic spotting on Evan's Early (X $\frac{3}{4}$). (h) and (i) Chlorotic spotting on Santa Rosa (Nat. size).

The most common symptoms of plum-mosaic on apricots in Central Otago are chevron patterns and yellow spotting of foliage, while in Auckland oak-leaf patterns and mosaic mottling are more common.

In Auckland where all transmission experiments have been conducted symptoms on European plums are less distinct than in southern areas, and also less distinct than on Japanese plums grown under the same conditions. On some varieties of European plums symptoms are difficult to detect under Auckland conditions.



Photos (a), (d) and (e) by R. I. Hughes. (b), (c) and (f) by P. R. Fry. (g) by S. A. Rumsey.

FIG. 4.—Symptoms of plum-mosaic on leaves of different plum varieties.

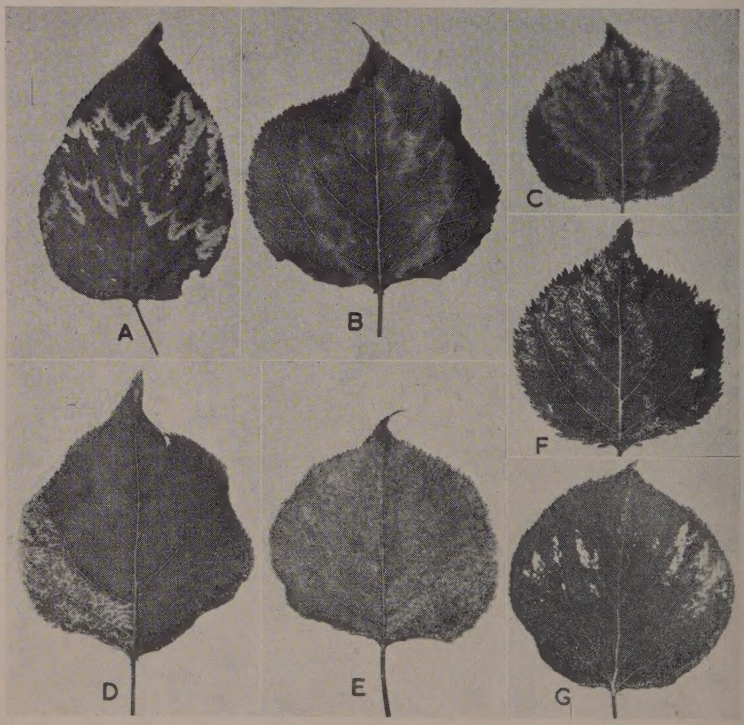
(a) Interveinal chlorosis on Monarch (X $\frac{3}{4}$). (b) Chlorotic spotting on Pershore (Nat. size). (c) Vague oak-leaf on Pershore (Nat. size). (d) Chlorotic spotting on Grand Duke (X $\frac{3}{4}$). (e) Oak-leaf on Grand Duke (X$\frac{3}{4}$). (f) Chlorotic spotting on Common Mussel (Nat. size). (g) Oak-leaf on Common Mussel (Nat. size).

Effect of Host on Symptom Expression:

Although there is a range of plum-mosaic symptom types which appear to be common to all susceptible stone fruit species, certain symptoms are characteristic of a particular species. Thus chevron patterns

(Fig. 5a) which are the most common symptoms on apricots have not been observed on other species. Similarly within a species certain varieties show characteristic symptoms. This is illustrated with the Japanese plum, Santa Rosa, in which infection causes a creamy-white to yellow spotting of foliage, spots tending to be aggregated towards the tips or centre of leaves (Fig. 3h, 3i). Other varieties also show characteristic symptoms, differences shown within the cherry plum group being of particular interest. Most cherry plums grown in New Zealand originated from seed, and show considerable differences in tree type. Observations indicate that these differences may have an effect on symptom expression, as on one tree type vein-banding is the usual symptom while on another oak-leaf patterns are most common.

Results of cross inoculation experiments (Tables II, III and IV) indicate that the different symptoms are caused by the same virus.

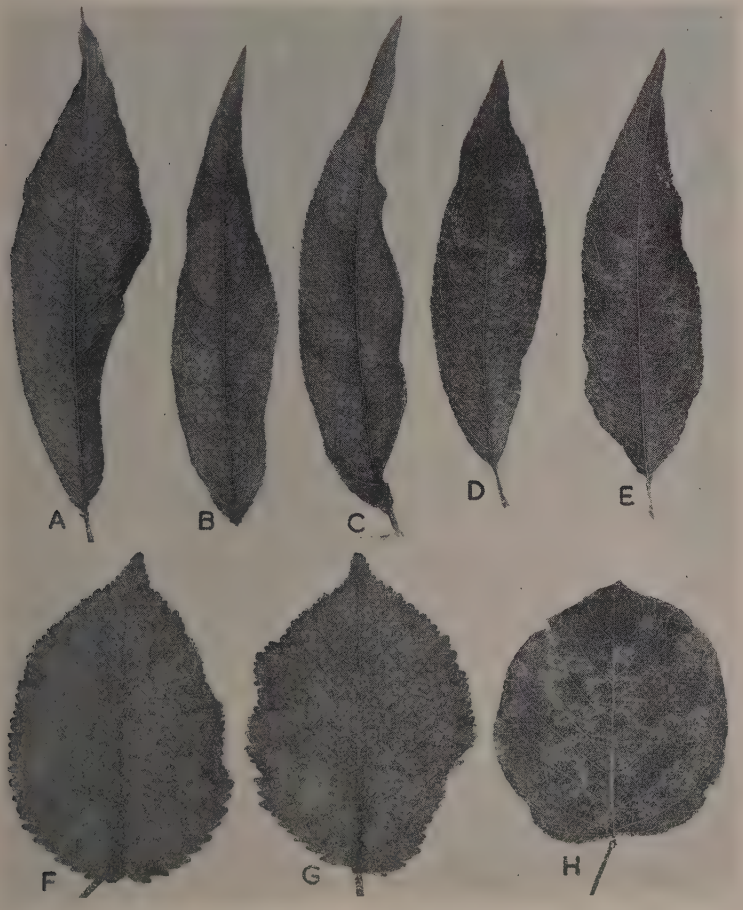


Photos (a), (f) and (g) by R. I. Hughes. (b), (d) and (e) by S. A. Rumsey. (c) by P. R. Fry.

FIG. 5.—Symptoms produced by plum-mosaic on leaves of apricot. (a) Chevron patterns on Moorpark (X $\frac{3}{5}$). (b) Vague oak-leaf on Newcastle (X $\frac{4}{5}$). (c) Vague oak-leaf on Moorpark (X $\frac{1}{2}$). (d) Vein-banding on Newcastle (X $\frac{2}{10}$). (e) Mosaic mottling on Newcastle (X $\frac{1}{2}$). (f) Chlorotic spotting forming vague oak-leaf on Dundonald (X $\frac{1}{2}$). (g) Chlorotic spotting on Newcastle (X $\frac{3}{5}$).

Effect of Strain of Virus on Symptoms:

There is some evidence that symptom differences may be caused in part by differences in strain of virus. Thus the plum-mosaic virus causing pronounced symptoms on apricots, when transmitted to cherry plum produces, in addition to the normal vein-banding and oak-leaf patterns, a rather unusual ring-spot condition (Fig. 1).



Photos by S. A. Rumsey.

FIG. 6.—Symptoms produced by plum-mosaic on different *Prunus* species. (a) Vague oak-leaf on Golden Queen peach (X ⅔). (b) Mosaic mottling on Golden Queen peach seedling (X ⅔). (c) Mosaic mottling on nectarine seedling (X ½). (d) Chlorotic spotting on Carmen peach (X ¾). (e) Vague oak-leaf on Monavale almond (X ½). (f) and (g) Pale red and chlorotic ring-spots on Sour Cherry stock (X ⅔). (h) Pale ring-spotting on Mahaleb cherry stock (X ⅔).

TABLE I. SYMPTOMS OF PLUM-MOSAIC IN THE FIELD AND ON EXPERIMENTALLY INFECTED HOSTS

Variety.	Description of Symptoms.	Fig. No.
CHERRY PLUM OR MYROBALAN (*P. cerasifera*)		
Cherry Plum	Vein-banding, oak-leaf, ring-spotting, mosaic mottling.	1, 2a, 2b.
Pissardi	Vein-banding.	
EUROPEAN PLUM (*P. domestica*)		
Blue Diamond	Yellow spotting.	
Climax	Oak-leaf.	
Coe's Golden Drop	Oak-leaf.	
Evan's Early	Oak-leaf, yellow-spotting, ring-spotting.	3f, 3g.
Grand Duke	Oak-leaf, yellow-spotting, ring-spotting, interveinal chlorosis.	4d, 4e.
Greengage	Oak-leaf, yellow-spotting, interveinal chlorosis.	
Kirk	Pale green oak-leaf.	
Monarch	Oak-leaf, interveinal chlorosis.	4a.
Pershore	Oak-leaf, yellow-spotting, mosaic mottling.	4b, 4c.
President	Interveinal chlorosis.	
Washington	Oak-leaf.	
Yellow Magnum Bonum	Vein-banding, oak-leaf.	
P. insititia		
Black Damas	Oak-leaf.	
Common Mussel	Oak-leaf, mosaic mottling.	4f, 4g.
JAPANESE PLUM (*P. salicina*)		
Alpha	Vein-banding, oak-leaf.	
Billingtons Early	Vein-banding, oak-leaf, ring-spotting, interveinal chlorosis.	
Black Doris	Oak-leaf, ring-spotting, mosaic mottling.	2c.
Burbank	Vein-banding, oak-leaf, ring-spotting.	
Doris	Vein-banding, oak-leaf.	
George Wilson	Vein-banding, oak-leaf.	
Hale	Vein-banding, oak-leaf, mosaic mottling.	3a, 3b, 3c.
June Blood	Vein-banding.	
October Purple	Vein-banding.	
Purple King	Vein-banding, oak-leaf.	2d, 2e.
Santa Rosa	Chlorotic spotting—spots often clustered at centre or tips of leaves.	3h, 3i.
Satsuma	Vein-banding, oak-leaf, ring-spotting.	
Sharpe's Early	Vein-banding, oak-leaf.	
Shiro	Vein-banding.	
Vailes	Vein-banding, oak-leaf.	
Victory	Vein-banding, interveinal chlorosis.	
Wright's Purple	Yellow-spotting, interveinal chlorosis.	
UNKNOWN PLUM SPECIES		
Morrison's Plum Stock	Vein-banding, oak-leaf. yellow spotting.	3d, 3e.
European Type Plum Stock	Chlorotic ring-spotting—each spot consists of a double ring.	2f.
PEACH (*P. persica*)		
Carmen	Faint oak-leaf, chlorotic spotting, ring-spotting.	6d.
Golden Queen	Faint oak-leaf, ring-spotting.	6a.
Golden Queen Seedlings	Faint oak-leaf, mosaic mottling.	6b.
Kahuranaki	Faint oak-leaf, ring-spotting, mosaic mottling.	
Royal George	Faint oak-leaf, ring-spotting, mosaic mottling.	
Sneed	Vein-banding, mosaic mottling.	
Wiggins	Vein-banding, oak-leaf.	

TABLE 1. Continued

Variety.	Description of Symptoms.	Fig. No.
NECTARINE (*P. persica*)		
Seedlings	Faint oak-leaf, ring spotting, mosaic mottling.	6c.
APRICOT (*P. armeniaca*)		
Dundonald	Oak-leaf, interveinal chlorosis.	5f.
Moorpark	Oak-leaf, chevron pattern, yellow spotting.	5a, 5c.
Newcastle	Vein-banding, oak-leaf, chevron pattern, yellow spotting, mosaic mottling.	5b, 5d, 5g, 5e.
Roxburgh Red	Chevron pattern.	
ALMOND (*P. communis*)		
Monavale	Faint oak-leaf.	6e.
Mahaleb Cherry Stock (*P. mahaleb*)	Oak-leaf, light green ring-spotting, mosaic mottling.	6h.
Sour Cherry Stock (*P. cerasus*)	Red or chlorotic spots, ring-spots and oak-leaf patterns.	6f, 6g.

TRANSMISSION OF PLUM-MOSAIC

Natural Transmission:

Although field observations suggest that natural spread of plum-mosaic may occur there is no definite evidence that transmission can take place other than by budding or grafting. It would appear, in Auckland at least, that natural spread, if it does take place, does not do so readily, as although diseased trees are present in both the plum orchard and the nursery at the Plant Diseases Division no spread has been observed during the three years that trees have been kept under close observation.

Transmission by Budding:

Transmission experiments were carried out by budding, the following three procedures being used:—

(1) Infected stocks were worked with buds from healthy trees and transmission of the disease to scions noted;

(2) Healthy stocks were worked with buds from infected trees and a record kept of disease transmission to stocks;

(3) Healthy stocks were worked with buds from both infected and healthy trees and observations made on transmission from diseased scions through the stocks to healthy scions.

TABLE II. TRANSMISSION OF PLUM-MOSAIC FROM INFECTED CHERRY PLUM STOCKS TO HEALTHY SCIONS: HEALTHY BUDS INSERTED IN INFECTED CHERRY PLUM STOCKS

Scion Variety.	No. trees budded.	No. buds surviving.	No. scions infected.
Cherry Plum	12	12	12
Billington's Early	5	5	5
Santa Rosa	3	3	3
Doris	6	4	4
Purple King	3	3	3
Monarch	6	6	6
Yellow Magnum Bonum	3	3	1
Satsuma	3	3	0
Coe's Golden Drop	3	2	2
Grand Duke	3	3	0
Greengage	3	3	3
President	3	3	3

Results, given in Tables II, III, IV and V show that transmission was readily secured by all three methods.

Throughout these trials symptoms produced on cherry plum were the same, irrespective of the host from which buds were taken, except that where infected apricot was used cherry plum stocks sometimes developed a chlorotic ring-spotting which did not occur with other hosts. In all cases where the disease was transmitted from cherry plum to other hosts, symptoms produced were identical with those occurring naturally on the same hosts.

TABLE III. TRANSMISSION OF PLUM-MOSAIC FROM NATURALLY INFECTED TREES TO HEALTHY CHERRY PLUM STOCKS BY BUDDING : DISEASED BUDS INSERTED IN HEALTHY CHERRY PLUM STOCKS

Scion Variety.	No. stocks worked.	No. stocks infected.
Cherry Plum	18	17
Santa Rosa	3	3
Wright's Purple	2	2
Grand Duke	3	3
English Plum Stock	3	2
Newcastle Apricot	5	5
Moorpark Apricot	3	3
Dundonald Apricot	2	2

TABLE IV. TRANSMISSION OF PLUM-MOSAIC FROM CHERRY PLUM TO VARIOUS PRUNUS SPECIES BY WORKING HEALTHY TREES WITH INFECTED CHERRY PLUM BUDS

Host Budded.			
Varietal and common names.	Botanical name.	No. trees budded.	No. trees infected.
Alpha plum	*Prunus salicina*	1	1
Black Doris plum	,, ,,	1	1
Doris plum	,, ,,	1	1
Hale plum	,, ,,	1	1
Purple King plum	,, ,,	1	1
Wilson's Early Seedlings	,, ,,	6	2†
Grand Duke plum	*P. domestica*	1	1
Petite'd Argen plum*	,, ,,	1	0
President plum*	,, ,,	1	0
Cherry Plum	*P. cerasifera*	9	9
Pissardi	,, ,,	1	1
Peach Seedlings (Golden Queen)	*P. persica*	12	12
Nectarine seedlings	,, ,,	11	11
Apricot seedlings	*P. armeniaca*	9	2†
Sour Cherry Stock (Seedlings)	*P. cerasus*	11	8†
Mahaleb Cherry Stock (Seedlings)	*P. mahaleb*	9	9

* On these varieties budding was carried out with immature buds in early December. Buds did not survive so it is possible that organic union did not occur.

† These counts were taken during the spring immediately following budding. Experience has shown that symptoms sometimes fail to appear until the second season after budding.

TABLE V. TRANSMISSION OF PLUM-MOSAIC BY WORKING HEALTHY STOCKS WITH HEALTHY AND INFECTED BUDS

Stock.	Infected scion.	Healthy scion.	No. trees budded.	No. healthy scions infected.
Black Damas Plum	Cherry Plum	Carmen Peach	4	2
Black Damas Plum	,, ,,	Golden Queen Peach	1	1
Peach Seedlings (Golden Queen)	,, ,,	Monavale Almond	6	6

EFFECT OF PLUM-MOSAIC ON PERCENTAGE BUD SURVIVAL ON CHERRY PLUM STOCKS

During 1947, observations were made on a mixed line of healthy and plum-mosaic infected cherry plum stocks which had been worked with buds of the apricot varieties Moorpark and Newcastle. It was noticed that on infected stocks the percentage bud survival appeared to be less than on healthy stocks.

In the following year, among experiments on transmission of plum-mosaic, healthy buds of 15 varieties of plum were worked to infected cherry plum stocks. In the four varieties, Burbank, Duff's Early Jewel, Sultan and Wilson's Early, no buds survived when worked to infected stocks although there was a satisfactory survival when buds of the same varieties were worked to healthy cherry plum stocks.

Photos by S. A. Rumsey.

FIG. 7.—Effect of plum-mosaic on survival of Burbank plum buds worked on cherry plum. Infected cherry plum stock on left showing dead buds and healthy cherry plum stock on right showing live buds.

As the above observations suggested that the disease influenced bud survival in some apricot and plum varieties, a preliminary experiment to test this effect was carried out in 1949. Over fifty buds, each of Burbank plum and Roxburgh Red apricot, were worked to a single healthy cherry plum stock and a similar number of each variety to a single infected stock. Bud wood of each variety was taken from the same tree and the work was carried out by one man under comparable conditions. Results, given in Table VI, indicate that the disease has a marked effect on bud survival. The effect of plum-mosaic on bud survival is illustrated in Fig. 7.

Table VI. Effect of Plum-mosaic on Percentage Bud Survival on Cherry Plum Stocks: Healthy Buds inserted in Infected Stocks, February, 1949; Survival Counts taken, October, 1949

Type of Stock.	Scion Variety.	No. buds inserted.	No. buds surviving.
Healthy Cherry Plum	Burbank Plum	59	56
,, ,, ,,	Roxburgh Red Aprivot	54	54
Plum-mosaic infected Cherry Plum	Burbank Plum	54	0
	Roxburgh Red Apricot	52	11

Identity of Plum-mosaic

Plum-mosaic occurring in New Zealand appears to be similar to the line-pattern virosis of Shiro plum as described by Willison (1945) from Ontario. The two diseases have a similar range of symptoms and hosts, both are readily transmitted by budding, and symptoms of both are most pronounced in the spring and autumn. They differ only in minor features such as symptoms on Mahaleb cherry seedlings and in the failure of line-pattern virosis to produce symptoms on apricot. It would appear that the same virus causes both the New Zealand plum-mosaic and the North American line-pattern of Shiro plum, but that there may be some difference in strain in the two countries.

By securing infective material from Cation who had described a line-pattern virosis of the genus *Prunus* in Michigan (Cation, 1941), Willison (1945) was able to compare it with his Shiro line-pattern virosis. Symptoms of these two viruses on differential hosts were so similar that he concluded that they were closely related if not identical. Comparison of symptoms described by Cation (1941) with those of the New Zealand plum-mosaic suggest that these two diseases are also similar.

A mosaic of Santa Rosa and other Japanese plum varieties occurring in a number of counties in California and described and illustrated by Thomas and Rawlins (1939) appears to be similar to the New Zealand disease. Not only do symptoms on Santa Rosa (Thomas and Rawlins, 1939; Fig. 5a) appear to be identical with those of plum-mosaic on this variety in the Dominion (Figs. 3h, 3i), but symptoms on myrobalan also appear to be the same for both viruses.

Although there are many other records of virus diseases attacking plums in the United States of America, descriptions indicate that they either differ from the New Zealand disease or available information is insufficient to allow comparisons to be made.

A virus disease of European plums, cherry plum, apricots and peaches in France described by Arnaud and Arnaud (1936) resembles in many respects the plum-mosaic occurring in New Zealand, although its range of symptoms appears to be less. Symptoms of stone fruit viruses occurring in Bulgaria (Atanasoff, 1935; Christoff, 1938) also resembles in some respects those of the New Zealand plum-mosaic, but the presence of fruit symptoms on the former suggests that a different virus is involved.

CONTROL

Experiments on Heat Treatment of Infected Cuttings:

In the United States of America it has been shown that several stone fruit viruses including peach yellows and phony peach could be destroyed in budwood by heat treatment without killing the plant tissues (Kunkel, 1936; Hutchins and Rue, 1939). A trial was therefore carried out to ascertain if plum-mosaic virus in cherry plum cuttings could be killed in a similar manner.

TABLE VII. HEAT TREATMENT OF CHERRY PLUM CUTTINGS: 50 CUTTINGS PER TREATMENT; 30 MINUTES IMMERSION

Temperature of Water.	No. Cuttings struck.	No. trees infected.
18°c.	24	22
38·0°c.	25	22
40·5°c.	26	21
43·5°c.	22	21
46·5°c.	20	18
49·0°c.	0	—

Cuttings approximately $\frac{1}{4}$ to $\frac{3}{8}$ inch diameter and 10 inches long taken from infected cherry plum trees were immersed in water, held at a constant temperature, for 30 minutes. After treatment cuttings were removed from the water bath, plunged into cold water, and then lined out in rows to strike. Counts of the number of cuttings which had struck, and the number showing infection were made in the following autumn. Results given in Table VII show that under the conditions of the experiment the thermal death point of the virus was at least as high as that of the cuttings. It would, however, be necessary to use a wider range of temperatures and times of immersion before a definite conclusion could be reached concerning the possibility of destroying plum-mosaic virus in living tissues by heat treatment.

Comparison of results obtained in these experiments with those secured in the United States of America indicate that the thermal death point of plum-mosaic is higher than that of peach yellows.

Elimination of Plum-mosaic from Nursery Beds by Rogueing and Selection of Cuttings from Healthy Trees:

In one nursery during the autumn of 1947 all visibly diseased plants were rogued from a line of approximately 4,000 young cherry-plum rooted cuttings which showed over 5 per cent infection. In the following spring this line showed less than 2 per cent infection. Trees showing disease were again rogued, and when examined in the autumn of 1948 no infected stocks could be found. By securing cuttings from the healthy

stocks and by rogueing infected cuttings as soon as observed, plum-mosaic has been almost eliminated from the cherry plum stock beds of this nursery, incidence being only 0.23 per cent when the beds were rogued in February 1950.

Recommendations for Control:

From the information available it would appear that healthy young trees may be secured if the following precautions are taken:—

(1) Cuttings for vegetatively reproduced stocks are selected from disease-free trees;

(2) Rootstock beds are carefully examined and all stocks showing symptoms of plum-mosaic removed and destroyed;

(3) Budwood is selected from healthy trees.

Acknowledgments

The authors wish to acknowledge assistance given by members of the Horticulture Division, Department of Agriculture, who forwarded diseased specimens from the field and secured material for budding experiments; and by Mr. C. A. S. Padfield of Fruit Research Station, Department of Scientific and Industrial Research, who carried out a survey of stone fruit orchards in Hawke's Bay.

References

Arnaud, G. and Arnaud, M. (1936): *C.R. Acad. Sci., Paris, 202,* 869-71.
Atanasoff, D. (1935): *Phytopath. Ztschr., 8,* 259-84.
Cation, D. (1941): *Phytopath., 31,* 1,004-10.
Christoff, A. (1938): *Phytopath. Ztschr., 11,* 360-422.
Hutchins, L. M. and Rue, J. E. (1939): Abs. in *Phytopath., 29,* 12.
Kunkel, L. O. (1936): *Phytopath., 26,* 809-30.
Thomas, H. Earl and Rawlins, T. E. (1939): *Hilg., 12,* 623-44.
Willison, R. S. (1945): *Phytopath., 35,* 991-1,001.

MEASUREMENT OF THE DISTRIBUTION OF GRANULAR SUPERPHOSPHATE FROM AEROPLANES

RESULTS OF A TRIAL AT THE OHAKEA AERODROME

By Jean Miller, Extension Division, Department of Agriculture, Wellington

(*Received for publication, 14 December 1949*)

Summary

An experiment is described, in which granular superphosphate was top-dressed from an Avenger aircraft on to 48 acres of Ohakea Aerodrome, and the resulting ground distribution pattern measured.

Over the whole area the density varied from nil to 7 cwt per acre, with large regular changes in density across the directions of flight but with no regular changes along the lines of flight. The mean density was 2.69 cwt per acre.

Detailed measurements were taken in one line at right angles to the line of flight and the resulting "wave formation" of the sample weights studied.

Detailed measurements were also taken along one line of flight but the results showed no significant trends.

Introduction

Campbell[1] has given details of the factors which led to the commencement of experiments with the distribution of fertilizers from aeroplanes, and his article on preliminary trials at Ohakea contains details of the Avenger Aircraft used in the trials and of the fertilizer hopper which was attached to the aeroplanes for the purposes of the trials. The Royal New Zealand Air Force, in conjunction with the Government Departments associated with the Soil Conservation and Rivers Control Council, subsequently conducted an extensive field trial over some 1,000 acres of hill country in the Wairarapa district.

Measurements of distribution by the Department of Agriculture in the Wairarapa trials indicated that, although generally satisfactory and probably at least as good as that obtained by hand top-dressing, the spread of fertilizer was in some cases not as even as could be desired. It appeared that the skill of the operators, both pilots and ground staff, in conjunction with local flying and meteorological conditions, greatly affected the accuracy obtained in the distribution of the fertilizer.

Practical difficulties associated with the measurement of spread of fertilizer in hill country do not permit of the obtaining of an accurate picture of the results. It was therefore decided to conduct a detailed trial of fertilizer distribution from an aeroplane on flat land at the Ohakea aerodrome under good flying conditions, using skilled operators, and the refinements in flying and ground control technique which had been developed during the previous trials. On 9 September 1949 this experiment was carried out.

Experimental

An Avenger aircraft used in previous trials was the distributing agent, and the fertilizer dropped was double-screened hillside superphosphate with granules passing $\frac{3}{8}$ in. but retained on $\frac{1}{4}$ in. sieves. The weather was warm and almost calm during the three hours taken to conduct the trial, the direction and speed of the wind being:—

11 a.m. to 12 noon	..	120°	.. 7 m.p.h.
12 noon to 1 p.m.	..	150°	.. 7 „
1 p.m. to 2 p.m.	..	190°	.. 7 „
2 p.m. to 3 p.m.	..	190°	.. 8 „

The aircraft made six parallel lines of flight along the trial area, being guided into each by radio messages from a ground control unit which moved across the trial area a distance of two chains after each flight. The initial dropping position on each run was indicated to the pilot by flagging, and another flagging signal was given to him at 40 chains from the first. On receipt of this second signal he closed the hopper, retaining any superphosphate that had not been released by that time. Thus the total area top-dressed was 40 chains by 12 chains, i.e. 48 acres, and on it a total amount of six tons of superphosphate was dropped. The area was level and mostly covered with fairly short grass, but it was crossed by two concrete runways. Some measurements were taken using circular canvas samplers in two sizes, one of cross sectional area, 1 sq. yd., the other of 1 sq. ft., and supported on wire legs driven into the ground. The concrete runways were also used for some of the measurements, the catch on selected areas being swept up and collected.

First Set of Measurements

This set aimed at obtaining a picture of the general distribution pattern over the whole field. The large and small canvas samplers were set out in a rectangular grid of 110 sampling positions to more than cover the area over which the fertilizer was to be dropped. The grid comprised ten rows each containing 11 samplers. For the purpose of this investigation, rows are considered as being at right angles to the direction of flight, and lines as being parallel to the direction of flight.

Table I. Sample Values in Rectangular Grid

Direction of Flight ———>

	Row 1	Row 2	Row 3	Row 4	Row 5	Row 6	Row 7	Row 8	Row 9	Row 10	Means.
Line 1	0	0	0·1	0	0·1	0·1	0	0	0	M	
Line 2	M	5·0	5·6	7·3	3·9	6·0	4·6	5·1	4·3	M	5·22
Line 3	0	0·9	1·3	2·6	2·1	3·0	3·2	5·8	1·2	M	2·51
Line 4	0	0·2	0·8	0·7	1·3	0·6	2·8	2·2	2·2	2·5	1·38
Line 5	0	4·2	1·5	1·9	0·3	0·7	0·7	0·4	0·6	0·4	1·29
Line 6	0	0·9	3·1	4·5	3·8	3·6	4·9	6·3	3·3	0·7	3·80
Line 7	0	2·3	2·9	3·5	2·9	3·8	2·7	3·4	2·4	1·4	2·99
Line 8	0	0	1·2	0	0·3	0	0·3	0·4	0	M	0·28
Line 9	0	6·2	3·3	4·1	6·1	2·9	4·1	4·3	3·8	0·7	4·35
Line 10	0·2	0·2	0·4	0·5	0·2	0·8	0·4	0·4	1·2	0·1	0·51
Line 11	3·0	4·5	6·2	4·5	7·4	3·3	3·2	5·0	2·9	1·4	4·62
Means		2·44	2·63	2·96	2·83	2·47	2·69	3·33	2·11		

M indicates that the sample was missing.

TABLE II. ANALYSIS OF VARIANCE OF CENTRAL PORTION OF TABLE I

Due to.	Degree of Freedom.	Sum of Squares.	Mean Square.
Between lines	9	228·92	25·44
Between rows	7	5·23	0·73
Residual	63	36·71	1·38
Total	79	320·86	4·06

The lines were $1\frac{1}{5}$ chains apart, this distance being chosen to have catchers located at as many different distances as possible from the centre of the runs. The rows were five chains apart, and thus with ten rows in the grid a total linear distance of 45 chains was covered. Table I shows the weights collected in the samplers, converted into hundredweight per acre. As more than the trial area was covered by the grid, the marginal samplers often had zero catch, and that portion of the table within the double lines gives the catch obtained from what may be regarded as the trial area proper. Only that portion of the table so enclosed has been used in the calculations.

Table I and Table II (the analysis of variance of values in Table I) show that there are large differences between the lines of catchers, which are parallel to the direction of flight, but only small differences between the rows. The sampling positions were not located at random within the classification of rows and lines, so statistical tests have not been made of differences between rows and between lines. However, about 70 per cent of the total variation is accounted for by the differences between lines, i.e., by systematic transverse variation.

General mean	2.69	cwt. per acre.
Standard deviation	2.05	„ „ „ (a)
Standard deviation, allowing for the variation between rows and lines	1.17	„ „ „ (b)

The S.D. (a) indicates the variation between all samples, while S.D. (b) is a measure of local variation, which includes errors of measurement and sampling errors, but excludes variation due to the position in the grid.

The frequency of occurrence of sampling values was:—

0 to 1 cwt. per acre	25	samples.
1 to 2 „ „ „	7	„
2 to 3 „ „ „	12	„
3 to 4 „ „ „	14	„
4 to 5 „ „ „	10	„
5 to 6 „ „ „	5	„
6 to 7 „ „ „	5	„
7 to 8 „ „ „	2	„
Total ..	80	„

It is a little disconcerting to note the large number of samplers receiving less than 1 cwt. per acre, especially when it is remembered that the outside fringes of the area were excluded from this table. The distribution, apart from the first 25 samples, follows a normal frequency curve, with the majority of sample values lying between 2 cwt. per acre and 5 cwt. per acre.

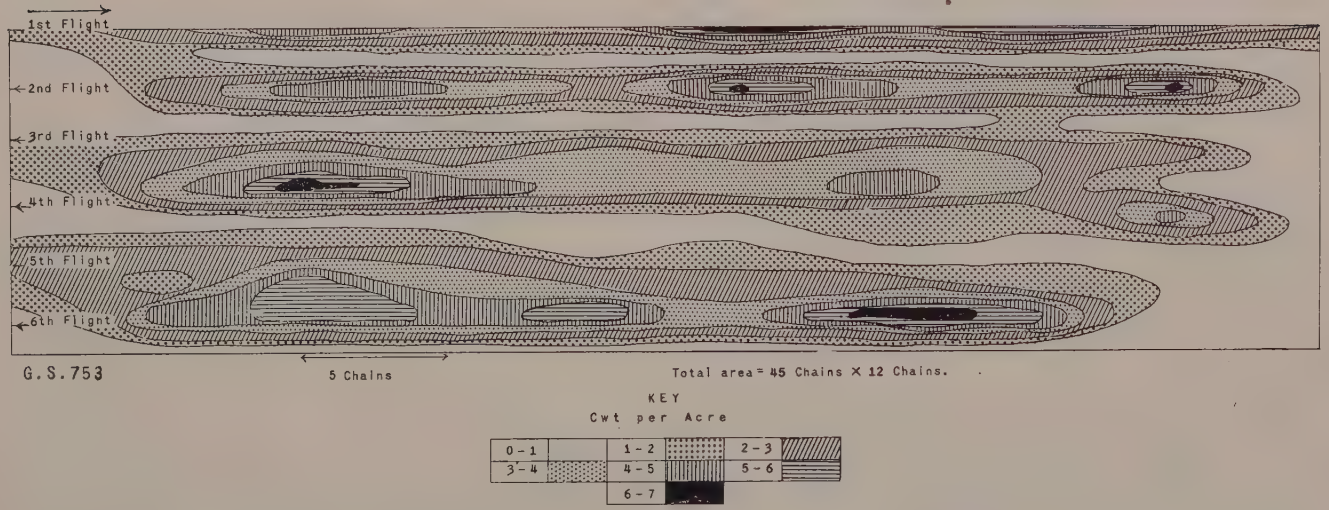


FIG. 1.—Map of the distribution over the whole field, showing lines of equal density.

Fig. 1 shows the resulting density distribution map, with equal density lines plotted from the above sample weights. The direction of flying was reversed after the first flight because of a change of wind direction, although the wind speed was very low all the time.

The map of Fig. 1 shows very clearly that the density follows a stated pattern, but the crests and troughs do not appear at the expected two-chain intervals. Apparently the spread from one run of the plane may sometimes markedly overlap that of the previous run. If this happens, an area may be left where little or no fertilizer falls, before the spread from the following run covers the ground. There is a possibility that the grid was not sufficiently close to detect all the peaks and troughs of the distribution. However, the next section shows that it is quite possible for one "hump" of the distribution to be four chains wide. With the number of samplers available, no closer grid could have been set up. Fig. 1 must then be considered as giving possibly an underestimate of the variability in density.

Second Set of Measurements

A series of measurements was taken at approximately 10-ft. intervals at right angles to the direction of flight, and covering the last four runs of the plane. The concrete runways mentioned above are laid out in hexagonal slabs of 6-ft. side, and one half of each consecutive hexagon was swept as was done by Campbell[1]. Slight inaccuracies were introduced through dust and small stones being already on the runway, but it was assumed that the errors were randomly distributed. Examination of the samples showed that the amount of stones was small in comparison with the amount of fertilizer. As the fertilizer hit the runway it bounced like hail, and again it had to be assumed that the errors due to pellets bouncing from one slab to another were randomly distributed. These assumptions seem justified in that the results in this section do not disagree with the results in the first section, as far as the sizes of means and errors are concerned.

As the width of hexagons was 10.39 ft., each sample came from approximately a 5-ft. length and has been considered to denote the density of fertilizer at the centre point of that 5 ft. The distance between samples is thus 10 ft. Fig. 2 is the graph of these sample values. That there is large variation, occurring in waves, is obvious. The second part of the graph, from point Z onwards, shows, as expected, consecutive troughs and peaks two chains apart. The first part of the graph, however, from point A to point Z shows one single large wave with period approximately four chains. This seems to indicate that the spreads from the first two runs overlapped to such an extent that the catches from the edges of each spread have been superimposed to give a prolonged peak of density more than 6 cwt. per acre. This of course left a wide trough of very low values before the next crest was attained. This overlap may have been caused by inaccuracies in flying or by a change in wind conditions between the two flights concerned. From the trough between the last two peaks, B and C, where there are no very low values, it seems that there is a certain amount of overlap between spreads, even when the peaks are two chains apart.

The distances between troughs were so irregular that no periodic curve would give a good fit, though it had been anticipated that the resultant accumulated distribution would be periodic, no matter what the distribution curve of each individual spread might be.

FIG. 2.—Graph of densities at a series of consecutive sampling positions ten feet apart, at right angles to the direction of flight.

Various parts of the distribution were therefore considered separately. The observations from Z to ZY were split into two separate peaks (called B and C); at ZK and ZL, the positions of overlap, half the observed value was allotted to each wave. The averages of the sample values at corresponding positions on the two peaks were computed to give what is referred to from now on as the "average peak." For a similar set of transverse measurements (of only one spread) Campbell[2] found that a normal curve gave an almost perfect fit. In the case considered here, however, a normal curve fitted to the "average peak" accounted for only 90 per cent of the variaton of values on that peak. Furthermore, a combination of two of the above normal curves overlapped so that their maxima occurred at the crests of the two observed crests, accounted for only 68 per cent of the variation in the original series. From Fig. 3 it can be seen that the discrepancy occurs at the maximum values where the curve of the observed values has a much flatter top than the normal curve. This was the case also when this normal curve was compared with each of the individual observed peaks, and it occurred also when a normal curve was fitted to each of the peaks separately.

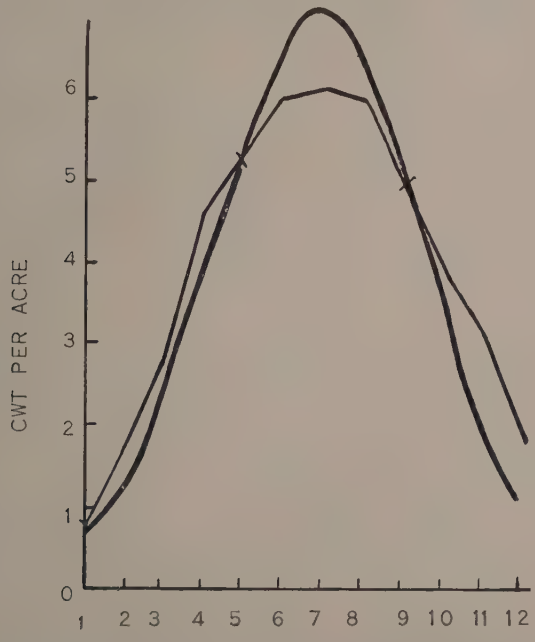


FIG. 3.—The "average peak," whose ordinates are the mean values of corresponding points on the two peaks C and D of Fig. 2, together with the normal curve fitted to these average values.

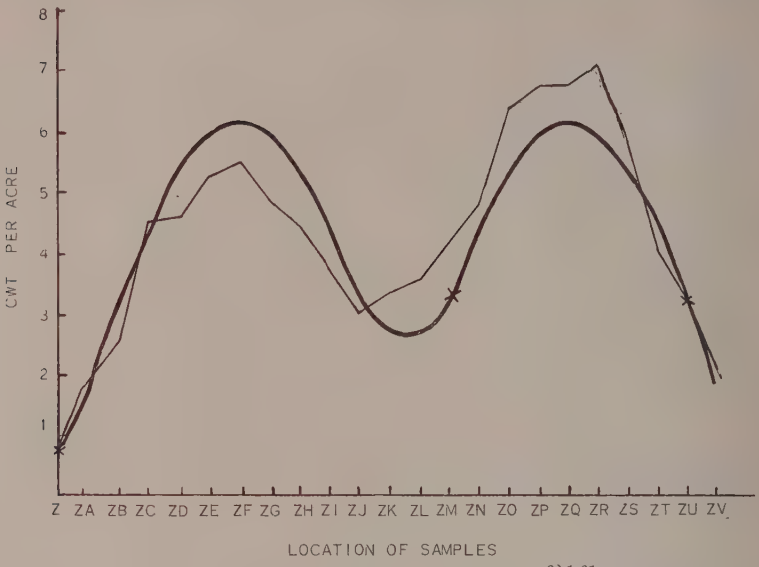


FIG. 4.—Curve produced by plotting $y = 6.13\ (1 - \frac{x^2}{49})^{1.61}$ twice with a distance of 114 ft. between the y axes, together with the observed values at points z to zy,

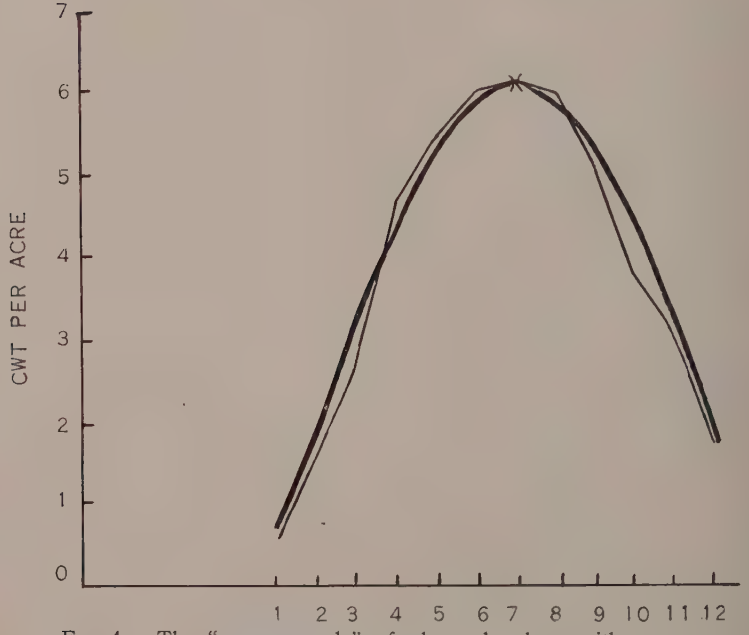


FIG. 4A.—The "average peak" of observed values, with $y = 6.13\ (1 - \frac{x^2}{49})^{1.61}$

The frequency constants calculated from the above "average peak" are, with the usual notation

$$\kappa_2 = 0$$
$$\beta_1 = 0$$
$$\beta_2 = 2.2$$

and on Pearson's criterion[3], a curve of the form $y = y_0 \left(1 - \frac{x^2}{a^2}\right)^m$ will give the best fit. Being a parabola this curve has no tails and is not likely to give a true picture of the edge conditions of the spreads. However, the curve $y = 6.13 \left(1 - \frac{x^2}{49}\right)^{1.61}$, fitted to the "average peak" accounts for 98 per cent of the variation, while two curves of this form, combined as before, account for 84 per cent of the variation in the original series. Figs. 4 and 4A illustrate this.

The form of the distribution suggests that a more even spread might be obtained by decreasing the distance between flights and the amount delivered at each run. As the mean density for this set of measurements was 3.5 cwt. per acre, it had to be assumed in the following calculations that the mean was required to remain at 3.5 cwt. per acre. Fig. 5 shows the resulting expected distribution with the fertilizer being dropped at 5/7 of the original rate and with a distance of $1\frac{2}{7}$ chains between flights. Fig. 5A shows a similar distribution with a dropping rate of 4/7 of the original and a distance of $1\frac{1}{7}$ chains between flights. In the distribution curve $y = y_0 \left(1 - \frac{x^2}{a^2}\right)^m$ the constant a determines the intersection point of the curve with the x-axis, i.e. the limit of spread of the particles. This will not be affected by the number of particles dropped. The constant m indicates the order of the parabola and can also be expected to remain constant. The equations used, therefore, in drawing Figs. 5 and 5A were $y = 4.38 \left(1 - \frac{x^2}{49}\right)^{1.61}$ and $y = 3.5 \left(1 - \frac{x^2}{49}\right)^{1.61}$ Fig. 5A gives an almost perfect expected distribution, with a distance of 75 ft. ($1\frac{1}{7}$ chains) between flights, and this figure is in good agreement with that found by Campbell[1], viz. 90 ft.

An attempt was made to relate that part of the original distribution shown by peak A of Fig. 2 to the above theoretical curve. Fig. 6 shows the sample values, with a curve obtained by plotting two overlapping cures of $y = 6.13 \left(1 - \frac{x^2}{49}\right)^{1.61}$ with a distance of 77 ft. 11 in. between their y-axes. This can be seen to give a very close fit from points C to M, but it fails from N to X. As this peak A in the observed values is markedly asymmetrical, no superimposition of a curve like $y = y_0\left(1 - \frac{x^2}{a^2}\right)^m$ on part of itself could give a good fit to both parts of the wave. It is understood that this more rapid falling-off of values is associated with the direction of draught from the propellor which, in one-engined aeroplanes such as were used in the trial, would tend to give skew distributions of the type shown. This effect is also seen, but to a less marked extent, in the curves of peaks C and D and in the combined curves (Figs. 4 and 4A).

The mean for this set of measurements is 3.46 cwt. per acre, which is considerably higher than the general mean. This set was taken fairly close to Row 8 of Table I, and this row had a mean of 3.3 cwt. per acre. This indicates that the high mean for Set 2 has not resulted from using hexagons instead of canvas catchers for measuring. As this row of catchers was almost at the end of the plane's run, it seems that there may be a greater rate of dropping when the hopper is almost empty. The third set of measurements attempted to test this but unfortunately complete records were not obtained.

Third Set of Measurements

A series of measurements was taken using the half hexagons of the other runway as units, at 48-ft. intervals parallel to the direction of flight, with the same assumptions about the location of the sample value at the mid-point as in the previous set of measurements. This set aimed to study more closely the change in dropping rate as the hopper emptied, and also to see how quickly the rate rose from zero to a steady level at the beginning of the run, and how it tailed off at the end. Unfortunately,

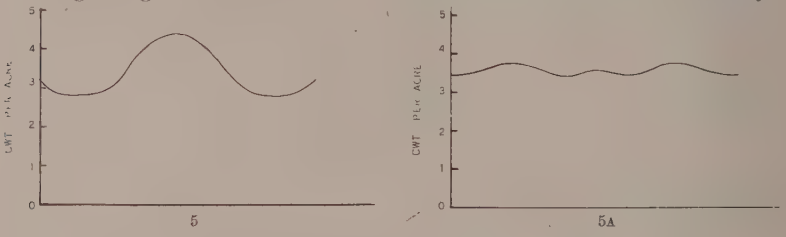


FIG. 5.—Expected distribution if the fertilizer is dropped at 5/7ths of the original rate, with $1\frac{2}{7}$ chains between runs.

FIG. 5A.—Expected distribution if the fertilizer is dropped at 4/7ths of the original rate, with $1\frac{1}{7}$ chains between runs.

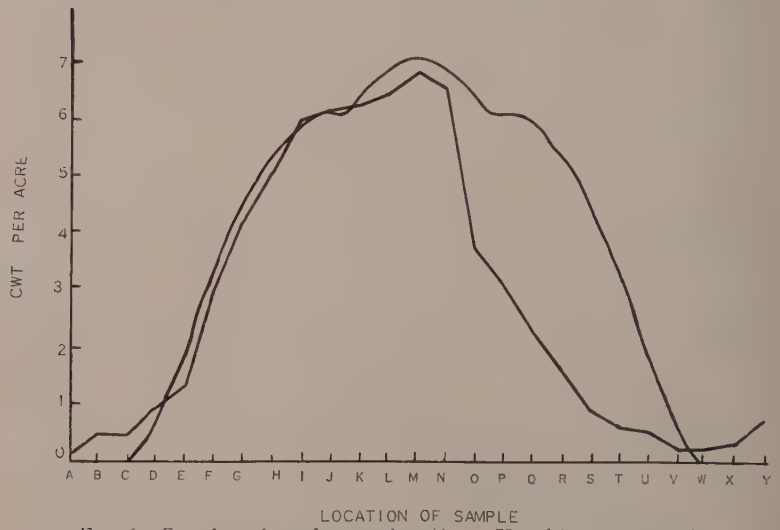


FIG. 6.—Sample values from points A to Y, with an expected curve formed by superimposing $y = 6.13\ (1 - \frac{x^2}{49})^{1.61}$ on part of itself.

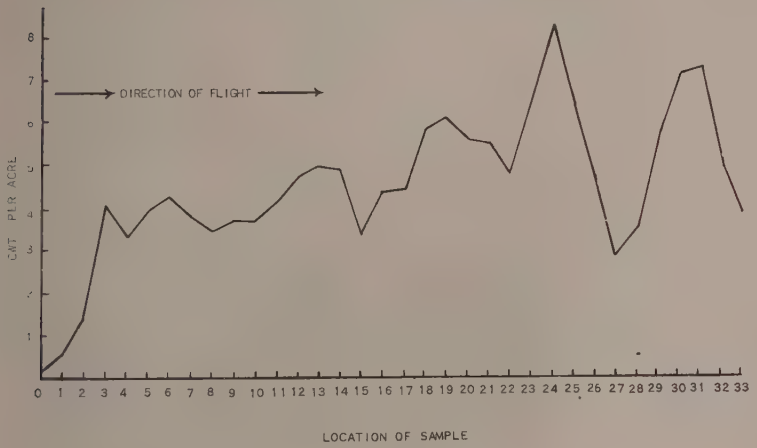


FIG. 7.—Graph of consecutive sample values in a line parallel to the direction of flight.

when the plane landed after this run it was unable to avoid crossing that part of the runway where the last part of the load had been dropped and all the end samples were blown away by the draught created. This set of measurements was taken along a line of fairly heavy density, mean, 4.52 cwt. per acre. Fig. 7 shows these sample values, plotted against the distance along the runway. There is no suggestion of a general rise or fall along the line. At the beginning, the density rises from zero to 4 cwt. per acre in four samples, i.e. in a distance of 190 ft. from the falling of the first particles. This set of measurements ends about Row 8 of Table I, where there seemed to be a rise in the rate of delivery of fertilizer, but there is no suggestion of a similar rise here. However, the variability is so great near this point that no indication is really given as to what is happening there. The standard deviation of this set of measurements is 1.92, which is somewhat higher than that obtained over all the field when the variation across and along the rows had been removed. The graph shows that there is much less variation between neighbouring samples at the beginning of the flight than at the end. A possible explanation is that the fertilizer flows more evenly when the hopper is full than when it is becoming empty.

ACKNOWLEDGMENTS

This experiment was made possible only by the co-operation of many people, and to all these the author's thanks are now expressed: to officers of the R.N.Z.A.F., of the Soil Conservation and Rivers Control Council, of the Extension Division, Palmerston North Office, and to a group of Massey College Students. Thanks are also due to Mr. K. Cottier for invaluable assistance in organizing the experiment and to Mr. E. R. Dearnley for all the computations.

REFERENCES

(1) CAMPBELL, D. A. (1948): *N.Z. J. Sci. Tech., A, 30,* 65-77.
(2) —— (1949): *N.Z. Sci. Rev., 7-9,* 155-60.
(3) PEARSON, K. (1931): Table for Statisticians and Biometricians, Pt. 1, p. lxiii, University Press, Cambridge.

STUDIES ON SOME NEW ZEALAND ROMNEY MARSH STUD FLOCKS

PART V. LOSSES IN EWES AND LAMBS.

By H. GOOT, Massey Agricultural College, Palmerston North

(*Received for publication, 13 December 1949*)

Summary

(1) The paper presents data on losses in breeding ewes and their offspring in two commercial studs during five seasons (1941-2 to 1945-6); it is based on 7,585 breeding ewes and 9,183 lambs.

(2) The average losses in breeding ewes consisted of 4.9 per cent of ewes which died and 2.1 per cent of ewes which were missing. Differences due to season and age, but not stud, were found to be statistically highly significant; the losses increased with advancing age.

During lambing there are highly significant differences between the pre-partum and post-partum mortality rates in ewes according to season and age.

(3) The mortality of lambs before docking, based on lambs *born* alive or dead, average 11.9 per cent.

INTRODUCTION

THERE is little factual information on the extent and causes of mortality in sheep. The difficulties in procuring reasonably accurate figures from farmers are recognized and have been discussed by White and Roberts (1927), Makings and Wynne (1945), Snedecor (1947) and others. In this country, Marshall (1945) had to admit that "in attempting to reduce sheep losses . . . to cold figures, one is largely obliged to rely on guesswork." Estimates taken from two sources of information available to him varied from one million to two and a half million sheep per annum and he concluded, therefore, that the loss is not less than five per cent.

SCOPE OF INVESTIGATION

The present communication is based on 7,585 breeding ewes and 9,183 lambs born in commercial stud flocks A and B (Goot, 1946), for the five-year period 1941-2 to 1945-6. It is concerned with (a) losses in ewes due to death, which have been recorded as such; (b) losses in ewes unaccounted for, the number of which are calculated from the difference between the number of ewes which should be present after recorded cullings, deaths, sales, etc., and the number actually present at a given time of the year, such as docking, shearing, etc.; and (c) losses in lambs before docking.

Losses in Breeding Ewes:

In this country the only data published on the death rate in Romney ewes, as far as the writer was able to ascertain, is that of Clarke (1947) who found that over a seven-year experimental period the death rate of ewes kept on highly improved and topdressed pastures averaged 5.6 per cent.

Tables I and II summarize the losses in breeding ewes according to years and age-groups. Since the differences between studs A and B were found, by the chi-square test (Snedecor, 1940), to be statistically non-significant, subsequent analyses were based on weighted means of both flocks.

TABLE I. PERCENTAGE OF DEAD AND MISSING EWES ACCORDING TO YEAR

(Percentages based on number of ewes put to the ram.)

Year	Ewes put to the ram No	Ewes		
		Dead (%)	Missing (%)	Total (%)
1941-2	1,930	4.51	3.21	7.72
1942-3	1,407	4.90	1.85	6.75
1943-4	1,364	5.13	0.44	5.57
1944-5	1,353	6.65	2.22	8.87
1945-6	1,531	3.85	2.42	6.27
Total and Average	7,585	4.94	2.12	7.07

TABLE II. PERCENTAGE OF DEAD AND MISSING EWES ACCORDING TO AGE

Age	Ewes put to the ram No.	Ewes		
		Dead (%)	Missing (%)	Total (%)
2-tooth	2,240	3.30	1.52	4.82
4-tooth	1,637	2.81	1.10	3.91
6-tooth	1,401	5.64	2.57	8.21
Full Mouth	1,019	5.40	3.14	8.54
5½ Years	674	7.72	3.56	11.28
6½ Years	345	9.86	1.74	11.59
7½ Years & over	269	13.01	4.09	17.10
Total and Average	7,585	4.94	2.12	7.07

TABLE III. PERCENTAGE OF DEAD AND MISSING EWES ACCORDING TO THE AGE AND THE TIME OF THE YEAR (PERIOD)

(Percentages based on the number of ewes put to the ram)

Period:-	I			II						III			IV					
Age	Between tupping and lambing			At Lambing						Between docking and shearing			Between shearing and tupping			TOTAL		
				At Parturition			After Parturition											
	d.	m.	Total	d.	m.	Total	d.	m.	Total	d.	m.	Total	d.	m.	Total	d.	m.	Total
2-tooth	.71	.27	.98	.40	-	.40	1.79	.13	1.92	.09	.09	.18	.31	1.03	1.34	3.30	1.52	4.82
4-tooth	.18	.06	.24	.98	-	.98	1.16	-	1.16	-	.18	.18	.49	.86	1.35	2.81	1.10	3.91
6-tooth	.79	.14	.93	2.00	-	2.00	2.07	.14	2.21	.43	.43	.86	.36	1.86	2.21	5.64	2.57	8.21
Full Mouth	.39	.20	.59	2.16	-	2.16	1.67	-	1.67	.79	.59	1.38	.39	2.36	2.75	5.40	3.14	8.54
5½ years	1.78	.15	1.93	1.93	-	1.93	2.52	-	2.52	.74	.59	1.33	.74	2.82	3.56	7.72	3.56	11.28
6½ years	2.32	.29	2.61	4.64	-	4.64	2.03	-	2.03	.58	.29	.87	.29	1.16	1.45	9.85	1.74	11.59
7½ years	3.72	1.49	5.21	3.72	-	3.72	3.72	-	3.72	1.12	.37	1.49	.74	2.23	2.97	13.01	4.09	17.10
Average	.84	.22	1.06	1.50	-	1.50	1.83	.07	1.90	.34	.30	.64	.42	1.53	1.95	4.95	2.12	7.07

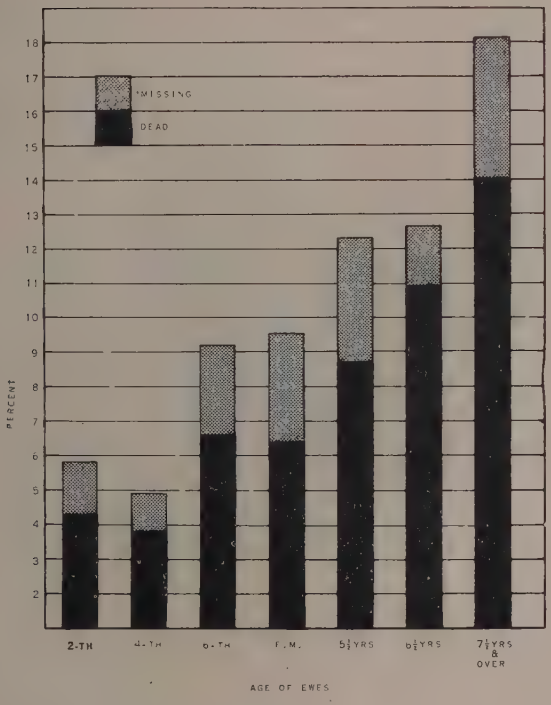


FIG. 1.—Losses in breeding ewes by age-groups.

Although the differences between years are statistically highly significant ($\chi^2 = 14.2$), this is due almost entirely to the results for the 1943-4 and 1944-5 seasons. Much bigger differences were found between age-groups (Table II). As expected there is a general increase in mortality with advancing age (Fig. 1); the small deflection at the age of 4-tooth is not significant statistically. A similar trend obtains in missing ewes. The age-group differences in mortality, in missing ewes, and in total losses, i.e. dead plus missing ewes, are statistically highly significant. In the latter case $\chi^2 = 118.3$ with 6 degrees of freedom.

Losses have also been classified into categories corresponding with the four periods into which each year can be conveniently divided. The periods were defined as follows:—

1. *Between tupping and lambing*: The period of approximately 4-5 months extending from the second week of March until lambing.

2. *At lambing*: The period extending from August to October approximately, and during which losses are further classified as:

(a) *at parturition*, the lamb being unborn;

(b) *after parturition*, the ewe being recorded as giving birth to a lamb (dead or alive) and further recorded as either dead or missing at docking time.

3. *Between docking and shearing*: The period from September to December approximately, the ewe being present at docking but not at shearing.

4. *Between shearing and tupping*: The period of approximately two and a half months from mid-December to the end of February, the ewe being present at shearing but not at mating.

The losses in these periods are shown in Table III. Of all the losses due to missing sheep, 72 per cent occurred in the last period, when one would expect the mortality to be at a minimum. This strongly suggests causes other than death to be responsible for this high wastage. Most careful inquiries, however, have failed to elucidate the fate of these sheep, although some unidentified dead sheep have been found in the paddocks. There is no record of these missing sheep having been culled, sold or killed. The possibility of theft cannot be overlooked. It should also be mentioned that at this time of the year much shifting of stock takes place and stray sheep, or sheep in badly fenced paddocks can readily be picked up in passing mobs.

The number of missing sheep in the first two periods is negligible, about four-fifths of losses in the first period and practically all in the second being due to mortality. They are therefore worthy of further consideration, particularly as they represent nearly 85 per cent of the average annual mortality.

TABLE IV. MORTALITY IN EWES DURING LAMBING ACCORDING TO YEAR

Year	At parturition (1)		After parturition (2)	
	No.	(%)	No.	(%)
1941	15	23.8	48	76.2
1942	25	47.2	28	52.8
1943	21	40.4	31	59.6
1944	42	63.6	24	36.4
1945	11	45.8	13	54.2
Total and Average	114	44.2	144	55.8

(1) lamb not born.

(2) lamb born, alive or dead.

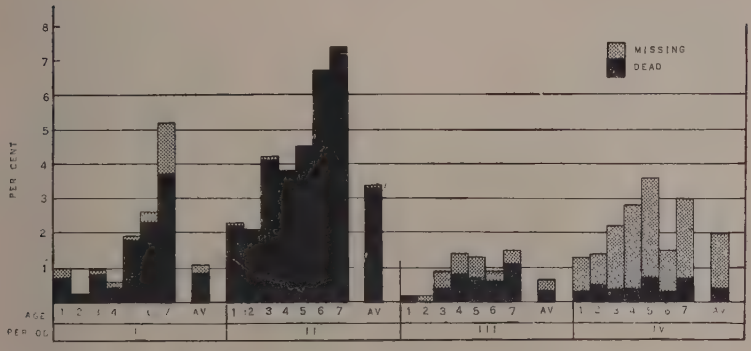


FIG. 2.—Losses in breeding ewes by age and period of the year.

Age: 1 = 2-tooth; 2 = 4-tooth; 3 = 6-tooth; 4 = F.M.; 5 = 5½ yrs.; 6 = 6½ yrs.; 7 = 7½ yrs. and over; Av. = average (cf. Table IV).

TABLE V. MORTALITY IN EWES DURING LAMBING ACCORDING TO AGE

Age	At parturition (1)		After parturition (2)	
	No.	(%)	No.	(%)
2-tooth	9	17.3	43	82.7
4-tooth	16	45.7	19	54.3
6-tooth	28	47.4	31	52.6
Full-mouth	22	56.4	17	43.6
5½ years	13	43.3	17	56.7
6½ years	16	69.6	7	30.4
7½ years and over	10	50.0	10	50.0
Total and Average	114	44.2	144	55.8

(1) lamb not born.

(2) lamb born, alive or dead.

In the first period (Table III and Fig. 2), the losses were less than one per cent up to the age of full-mouth, but increased rather rapidly in subsequent age-groups. Similarly in the second period the mortality increased with advancing age and only the 2-tooths and 4-tooths were below the flock average.

Table IV shows the percentage of ewes which died at parturition and after parturition (periods 2a and 2b). Over the years more losses occurred after parturition except in the 1944 season. The differences between years are statistically highly significant ($\chi^2 = 21.1$), although the heterogeneity is attributable entirely to the 1941 and 1944 seasons.

Losses in these periods grouped according to the age of ewes are shown in Table V. It will be seen that the bulk of the losses in 2-tooths occurred after parturition, and in 6½-year-old ewes at parturition. The highly significant chi-square, $\chi^2 = 24.1$, indicates that the differences are real, although based on small numbers.

Losses in lambs before docking:

In this country, Clarke (1947) found over the seven-year experimental period that 11.9 per cent of lambs born alive have died at birth or within three days, on the average. Barton (1947), examining records of a New Zealand Romney Marsh stud flock for the past 13 seasons, found 8.8 per cent of lambs either born dead or having died soon after birth.

TABLE VI. MORTALITY OF LAMBS BEFORE DOCKING BY YEAR AND STUD

(Percentage based on number of lambs born.)

Year	Stud	Lambs Born No.	Lambs dying before docking (%)
1941	A	1,773	9.6
	B	473	15.0
1942	A	1,311	12.3
	B	361	7.8
1943	A	1,273	12.3
	B	466	14.6
1944	A	1,148	12.7
	B	455	15.6
1945	A	1,331	9.8
	B	592	15.2
Total and Average	A	6,836	11.2
	B	2,347	14.0
	A + B	9,183	11.9

The mortality in lambs before docking is mostly due to lambs being stillborn, dying at birth or within three days or so after birth. Figures presented by Clarke (1947) indicate a sharp decline in mortality after the first three days, so that the accuracy of the present data is not unduly affected by the age of lambs at docking, which varied from one to four weeks approximately.

Seasonal and flock variations in lamb mortality are shown in Table VI. On the whole, the mortality in stud B was higher than in stud A, the reverse situation obtaining in one season only.

The mortality of lambs grouped according to the age of their dams is shown in Table VII. It will be seen that the 2-tooths lost the highest percentage of lambs, this being in accord with findings of Barton (1947). In stud A the mortality in lambs decreased with the increase in age of dams; this, however, did not obtain in stud B, and therefore further evidence is needed on this point.

TABLE VII. MORTALITY OF LAMBS BEFORE DOCKING BY AGE-GROUPS OF THEIR DAMS.

(Percentage based on number of lambs born.)

Age-groups of dams	Stud	Lambs Born No.	Lambs dying before docking (%)
2-tooth	A	1,643	15.95
	B	627	17.07
4-tooth	A	1,442	10.54
	B	525	9.90
6-tooth	A	1,373	10.05
	B	489	10.84
Full Mouth	A	1,041	9.41
	B	339	15.04
5½ years and over	A	1,337	8.53
	B	367	17.71

TABLE VIII. MORTALITY OF LAMBS BEFORE DOCKING, BY TYPE OF BIRTH AND AGE OF DAM; STUD B ONLY.

(Percentage based on number of lambs born within each type of birth.)

Age of Dams	Type of birth			
	Singles		Twins	
	Born	Died	Born	Died
	No.	(%)	No.	(%)
2-tooth	373	13.9	254	21.7
4-tooth	230	7.8	286	11.2
6-tooth	162	11.7	312	10.6
Full Mouth	106	13.2	206	14.1
5½ years and over	92	14.1	254	18.1
Total and Average	963	12.1	1,312	14.9

The mortality among lambs born as singles and twins in stud B, is given in Table VIII. The average mortality rate amongst twins was higher, by nearly three per cent, than amongst singles. Here again the 2-tooth ewes lost the highest percentage of lambs born as twins.

Among triplets the mortality was still higher; out of 72 lambs born as triplets in stud B, 17, or 23.6 per cent, died before docking.

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REFERENCES

BARTON, R. A. (1947): *Proc. Ann. Meeting Sheepfarmers,* Massey Agric. Coll., *10,* 113-19.

CLARKE, E. A. (1947): *Ibid., 10,* 30-46.

GOOT, H. (1946): *N.Z. J. Sci. Tech., A, 28,* 80-2.

MAKINGS, S. M. and WYNNE, A. G. (1945): Midland Agric. Coll. Loughborough, *Rept. Agric. Econ. Surv. Studies, 6.*

MARSHALL, D. (1945): *Proc. N.Z. Soc. Animal Prod., 5,* 21-5.

SNEDECOR, G. W. (1940): "Statistical Methods," The Iowa State College Press, Ames, Iowa.

——— (1947): *U.S. Livestock Sanitary Assoc. Ann. Meet., 51,* 218-25.

WHITE, R. G. and ROBERTS FRASER, J. A. (1927): *Welsh J. Agric., 3,* 70-9.

SOIL DISINFECTION

X. PRELIMINARY REPORT ON CONTROL OF HEAD SMUT (*Sorosporium reilianum* (Kühn) McAlpine) OF MAIZE (*Zea mays* L.)

By H. Jacks, Plant Diseases Division, Department of Scientific and Industrial Research, Auckland

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Summary

Sorosporium reilianum was found to attack maize crops in the Gisborne district of New Zealand.

Experiments carried out in the glasshouse and in the field showed that head smut was carried both by soil and seed. Soil-borne infection brought about higher incidence of the disease.

In the glasshouse complete control was secured by application of steam, chloropicrin, carbon disulphide and formalin; D-D gave inconsistent results.

Chloropicrin, D-D and Iscobromes I and II applied to smut-infected soil in the field, reduced infection, but were not effective in controlling the disease.

Introduction

Head smut (*Sorosporium reilianum* (Kühn) McAlpine) infection of maize crops in the Gisborne district of New Zealand was first reported in *New Zealand Journal of Agriculture* (1938), listed by Brien (1939), and described by Cunningham (1945).

It was observed during a visit to the maize growing area at Gisborne in 1946 that whereas some areas were free of the disease, others showed a considerable degree of infection. Crops were growing on similar soil types and the same variety of maize was sown throughout the areas observed. It was assumed that distribution of smut infection occurred through the use of contaminated seed. Heavy infection of the soil resulted later through continuous sowing of maize on areas thus infected initially.

Experiments were carried out to ascertain: (a) degree of infection from both soil- and seed-borne transmission, and (b) whether application of soil fumigants would control the disease.

Symptoms

Observation of the disease under glasshouse and field conditions gave the following results. Infection appeared to be systemic as mycelial strands were found in sections cut through stems in the vicinity of nodes. Vascular breakdown sometimes occurred causing collapse of plants. The first visible symptoms of the disease appeared with seed-head formation. A number of infected plants showed stunted growth (Fig. 1) and black powdery smut masses on tassels (male inflorescence) and ears (female inflorescence) (Fig. 2). The fact that abnormal flowering parts did not always contain spore masses suggested that spore production did not always follow infection.

Photo by L. H. Wright.

FIG. 1.—Effect of head-smut infection on plant growth. Left: Healthy. *Right*: Infected maize plant.

No definite relationship between infection of tassels and that of ears could be found. Healthy ears were observed on plants showing infected tassels, whereas infection of ears often appeared on plants with healthy tassels. Healthy and infected ears were often found on the same plant.

The male and/or female inflorescences of infected plants growing alone usually developed into leafy structures or a number of leafy shoots filled with black powdery masses of spores (Fig. 2. Abnormal proliferations were of whitish appearance due to their covering membrane, and appeared either on individual flowers or on the whole inflorescence. Viable seed was often present on the ears (Fig. 2). The spores escaped from membranes opened either at an early stage by friction between adjacent plants, or during harvesting operations.

Infected ears developed very thick leafy protection and the colour of the seed was duller than in healthy ears. A number of abortive ears showing leafy growth often appeared at nodes (Fig. 3). These did not always enclose smut spores.

EXPERIMENTAL METHODS

Spores for inoculation of seed or soil were collected from diseased tassels and ears, and their viability was tested in hanging drop cultures.

Photo by L. H. Wright.

FIG. 2.—Effect of head smut on formation of maize tassels and ears, showing proliferations caused by the disease.

Maize seed of the variety Marigold were taken from a disease-free crop. Inoculation of seed was carried out by steeping in a heavy spore suspension followed by drying.

Soil for experimental work was either inoculated with spores or taken from a field that had grown a smut-infected crop. Inoculated soil was prepared by mixing one ounce of spores with each cubic foot of steam disinfected soil. Naturally infected soil was taken from an area cropped with maize for the previous ten years. On an acre plot of this area, surveyed in detail to determine the degree of infection, of a total of approximately eleven thousand plants, 17.6 per cent were found to have infected tassels, 15.5 per cent, infected ears, while 0.5 per cent of plants showed complete collapse.

In glasshouse trials, plants were grown in 8-in. pots allowing twelve replications per treatment. A period of fourteen days was allowed between inoculation and/or soil fumigation, and date of sowing. Three maize seeds were planted in each pot and after emergence seedlings were thinned to allow one plant per pot. Records were completed four months after sowing.

Details of fumigants used in these experiments and method of preparing emulsions were given in an earlier paper (Jacks, 1946). Methods of application are given for each experiment.

Numbers of healthy and infected tassels and ears were recorded. Results, given in the tables, are expressed as percentage infection.

Photo by L. H. Wright.

FIG. 3.—Abortive ears appearing on some smut-infected maize plants.

Glasshouse Trials

Experiment 1

In this trial the effect of seed- and soil-borne infection was ascertained (Table I).

TABLE I. INCIDENCE OF MAIZE HEAD SMUT IN THE GLASSHOUSE. PLANTS GROWN FROM CLEAN OR INFECTED SEED OR SOIL

Treatment	Mean percentage infection.	
	Tassels	Ears.
Clean soil sown with clean seed	0·0	0·0
,, ,, ,, ,, infected seed	16·7	20·2
Infected soil sown with clean seed	41·7	42·1
,, ,, ,, ,, infected seed	75·3	66·7

All seeds germinated and no plants were killed by the disease. Healthy tassels and ears came from plants grown from clean seed in clean soil. Infection was considerably lower in plants derived from infected seed than in those grown from clean seed in infected soil. Seed- and soil-borne infection combined, brought about higher incidence of head smut than either alone.

Experiment 2

Naturally infected soil was sterilized by application of soil fumigants in concentrated form and at rates given in Table II. Methods of application have already been described by Jacks (1945, 1948); results are given in Table II.

TABLE II. INCIDENCE OF MAIZE HEAD SMUT IN THE GLASSHOUSE. EFFECT OF CHLOROPICRIN, D-D AND CARBON DISULPHIDE ON CONTROL OF THE DISEASE IN NATURALLY INFECTED SOIL

Treatment.	Quantities of concentrated fumigant per cu. ft. (ml.)	Mean percentage infection.		Mean number of healthy ears per plant.
		Tassels.	Ears.	
Check	—	83·4	46·7	1·2
Chloropicrin	10·0	0·0	0·0	2·6
D-D	10·0	0·0	0·0	2·0
Carbon disulphide	20·0	0·0	0·0	1·0
Difference required for significance at 5 per cent. level				0·7

Fumigants gave complete control of the disease and, with exception of carbon disulphide, significant increase in the number of ears per plant. The percentage of infected tassels in checks was almost twice the percentage of infected ears.

Experiment 3

For one treatment naturally-infected soil was steamed at 150° F. for 15 minutes before potting. For the other treatments and checks, soil from the same source was placed in pots, and fumigants in emulsified form were applied at rates given in Table III. Pots were covered with sacks for 48 hours after treatment and sown with clean seed.

TABLE III. INCIDENCE OF HEAD SMUT OF MAIZE IN THE GLASSHOUSE. EFFECT OF EMULSIFIED CHLOROPICRIN, D-D, CARBON DISULPHIDE, FORMALIN AND STEAM ON CONTROL OF THE DISEASE IN NATURALLY INFECTED SOIL

Treatment.	Quantity of fumigant in one gal. water applied to each cu. ft. (ml.)	Mean percentage infection.		Mean number of healthy ears per plant.
		Tassels.	Ears.	
Check	—	50·0	33·4	1·0
Chloropicrin	10·0	0·0	0·0	1·8
D-D	10·0	16·7	11·8	1·4
Carbon disulphide	20·0	0·0	0·0	1·7
Formalin	105·0	0·0	0·0	2·0
Steam at 150°F.	—	0·0	0·0	1·6
Difference required for significance at 5 per cent. level				0·6

All treatments except D-D gave complete control of the disease and increased production of ears. D-D gave only partial control and did not significantly increase the number of ears per plant.

Outdoor Trials

Experiment 4

An outdoor area was divided into twenty equally-sized plots each of 20 sq. ft., separated by asbestos board partitions sunk to a depth of 15 in. Treatments as shown in Table IV were replicated at random four times in a latin square design. Infected soil at the rate of 5 cu. ft. per plot was used in the season 1945-46, the inoculum being spread evenly over the surface of plots and worked in to a depth of 3 in. The trial was continued using the same plots and layout in the season 1946-47, the soil being inoculated with a freshly-prepared, soil-spore mixture applied in a similar manner. Emulsified chloropicrin and D-D were applied with a watering can at rates given in Table IV. A further half a gallon of water per square yard was sprayed on to the soil after application of fumigants. All plots were sown in October, fourteen days after treatment. Seedlings were thinned to allow ten plants per plot, and records were completed five months later.

TABLE IV. INCIDENCE OF HEAD SMUT OF MAIZE IN AN OUTDOOR TRIAL. EFFECT OF SEED- OR SOIL-BORNE INFECTION, AND CONTROL GIVEN BY EMULSIFIED CHLOROPICRIN AND D-D

Treatment.	Quantity of fumigant in 2 gal. water per sq. yd. (ml.)	1945/46 Mean percentage infection.		Quantity of fumigant in 2 gal. water per sq. yd. (ml.)	1946/47 Mean percentage infection.	
		Tassels.	Ears.		Tassels.	Ears.
Clean soil sown with clean seed	—	0·0	0·0	—	0·0	0·0
Clean soil sown with infected seed	—	26·9	17·7	—	5·6	22·5
Infected soil sown with clean seed	—	35·2	39·1	—	34·0	47·4
Infected soil treated chloropicrin*	10·0	26·1	30·3	20·0	17·7	21·7
Infected soil treated D-D*	10·0	36·7	42·6	20·0	18·7	26·8
Difference required for significance at 5 per cent. level		12·4	8·3		9·8	20·3

* Sown with clean seed.

Seed-borne infection occurred in both seasons, but infected soil brought about a higher incidence of diseased plants. At lower dosages, treatments failed to give satisfactory reduction of infection; at higher dosages, chloropicrin and D-D reduced infection but failed to control the disease.

Experiment 5

This trial was carried out on a field near Gisborne, where smut infection had been surveyed in the previous crop. The experimental area was divided into 30 plots each of 576 sq. ft. to allow five replications per treatment. Fumigants were applied on 4 November 1946 by means of an applicator (Fig. 4), drawn by a small tractor. This machine was not very accurate in measuring out the desired dosage of fumigants, ducts being frequently blocked. The depth of application varied between 0.5 and 2 in. owing to presence of undecayed organic matter and gravel in the soil. On 6 November 1946, seed was sown in rows 3 ft. apart, there

being three rows per plot. Germination appeared to be unaffected by early sowing of treated plots, and an early count showed approximately 70 plants per row. The centre row in each plot was examined to assess degree of infection. Records were taken on 16 April 1947 and approximately 300 plants were examined in each treatment. Results are given in Table V.

TABLE V. INCIDENCE OF MAIZE HEAD SMUT IN THE FIELD. EFFECT OF CHLOROPICRIN, D-D, CARBON DISULPHIDE AND ISCOBROMES I AND II ON CONTROL OF THE DISEASE

Treatment.	Quantities of concentrated fumigants per acre. (lb.)	Mean percentage infection.	
		Tassels.	Ears.
Check	—	31·0	24·1
Chloropicrin	378	13·4	8·1
D-D	225	16·8	12·7
Carbon disulphide	600	17·1	15·8
Iscobrome I	510	15·0	14·8
Iscobrome II	398	14·1	13·8
Difference required for significance at .5 per cent. level		7·5	9·3

All treatments brought about significant reduction of infection, but failed to control the disease. It is possible that shallow depth of application and dry soil conditions at the time and after treatment were responsible for the failure of fumigants at the fairly high dosage rates.

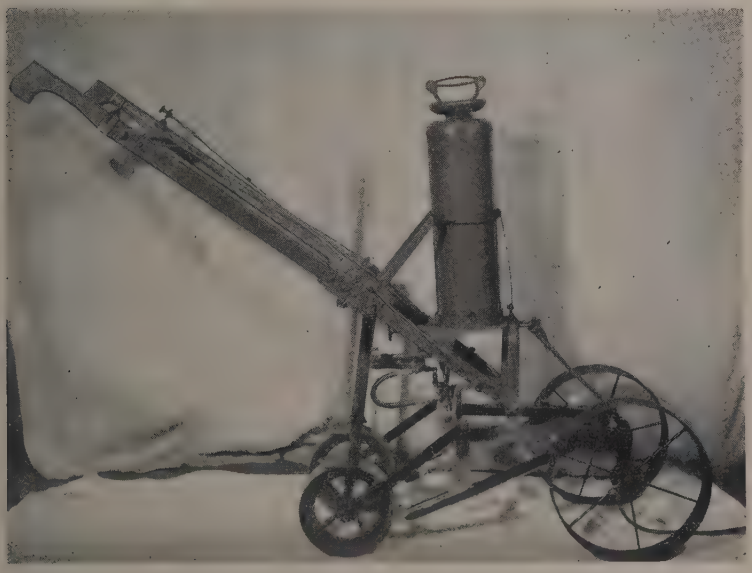

Photo: Courtesy Innis, Speiden & Co.

FIG. 4.—The manpowered C.F. Larvajector used for application of fumigants in the field. Front and rear wheels lowered for transporting the machine to and from working location.

Discussion

Results showed that soil- as compared with seed-borne infection brought about almost twice the incidence of head smut. Seed- and soil-borne contamination combined, induced a much higher percentage infection. Yield measured by recording numbers of healthy ears per plant was substantially reduced by the disease.

The application of fumigants appears to be uneconomical; however, better results were obtained by using the materials as concentrates rather than in emulsion. Conditions of soil moisture and depth of injection appeared to have definite influence on efficacy of treatments as shown by unsatisfactory results from large scale application of fumigants.

Acknowledgments

Appreciation is expressed for the valuable assistance given by the late Mr. V. P. Boot, Fields Instructor, Department of Agriculture, Gisborne, who helped with the collection of field data and in experimental work carried out in his district. Thanks are also due to Innis, Speiden & Co., New York, for the loan of a C.F. manpowered Larvajector.

References

Anon. (1938): Head smut in Maize. *N.Z. J. Agric., 56,* 184.

Brien, R. M. (1939): A List of Plant Diseases Recorded in New Zealand. *N.Z. Dept. Sci. Ind. Res. Bull. 67,* 34.

Cunningham, G. H. (1945): Additions to the Smut Fungi of New Zealand. *Trans. Roy. Soc. N.Z., 75,* 336-7.

Jacks, H. (1945): Soil Disinfection III. Chemical Treatments for Eelworm Control. *N.Z. J. Sci. Tech., A, 27,* 93-97.

—— (1946): Soil Disinfection V. Comparative Efficacy of Soil Fumigants for Control of Grass-grub. *Ibid., A, 28,* 166-72.

—— (1948): Soil Disinfection VI. Chemical Control of Verticillium-wilt of Tomatoes. *Ibid., A, 30,* 118-23.

INFLUENCE OF THE TYPE OF EWE UPON THE TYPE OF FAT LAMB CARCASS

By C. P. McMeekan and D. E. Walker, Ruakura Animal Research Station, Department of Agriculture, Hamilton

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Summary

(1) An experimental study has been carried out of the value of selecting, on the basis of carcass conformation, breeding ewes for fat lamb production.

(2) From three successive years' results over a total population of approximately 3,000 ewes, a very intensive selection potential of approximately 90 per cent for conformation resulted in only a very small difference in progeny groups.

(3) These results may be interpreted as indicating the marked dominance of the Southdown breed when crossed with the Romney in the production of meat animals, or, alternatively, since the Southdown was used on both extremes of carcass type, it is suggested that the results substantiate the low heritability estimates reported by various workers for carcass conformation in the Romney breed.

(4) From a production viewpoint the results indicate that for fat lamb breeding in New Zealand there is no material advantage in selecting breeding ewes for carcass conformation to the degree normally applicable in practice.

Introduction

In the production of fat lambs most farmers pay some attention to the carcass conformation of the breeding ewes employed. This is to be seen in the higher price commanded by the short legged, blocky type of ewe compared with the long legged, rangy type when other things are equal. It is to be seen also in the methods employed in home bred flocks where it is the practice to retain the better carcass types whenever this can be done.

This policy is understandable since the breeder expects "like to beget like." Recent studies by the statistical geneticist suggest, however, a very low heritability value for carcass conformation in the sheep; indeed, the heritability ratios reported by workers such as McMahon[1], Terrill and Hazel[2], and Rae[3] are so low that it can be well argued that little improvement in carcass conformation can be expected from straight selection of the ewe flock, and that the inclusion of this character in ewe-selection work reduces the rate of improvement in other more strongly inherited characters for which culling is inevitably restricted. While it does not necessarily follow that these low heritability estimates derived from studies within a pure breed apply to the cross-breeding work of fat lamb production, the conclusions reached do suggest interesting and important applications even to this class of breeding.

At Ruakura the authors are interested in elucidating and evaluating the various factors associated with efficiency of fat lamb production. In such studies it has been considered worthwhile to examine the relationship between the conformation of the fat-lamb breeding ewe and the carcass quality of her progeny.

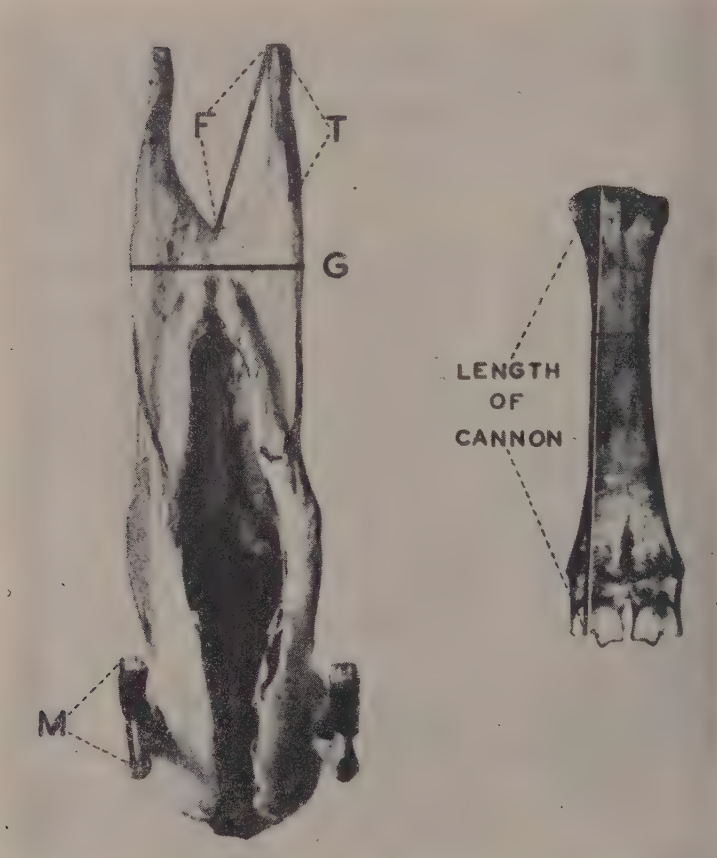

FIG. 1.

EXPERIMENTAL METHOD

The experiment was designed along the following lines:—From a group of approximately 1,000 ewes from the same origin, the top 10 per cent and the bottom 10 per cent were selected on a basis of carcass type or conformation. The remainder were discarded. The top 10 per cent were short legged ewes with a blocky carcass of good conformation from the point of view of meat production. The bottom 10 per cent were long legged, rangy ewes of poor carcass type. The resulting two groups were then mated to a Southdown ram or group of rams, the ewes running together as one flock from tupping until picking of the lambs. Lambs were picked by a professional fat-lamb picker as in normal commercial practice. Every lamb was examined on the hooks, the measurement system of carcass evaluation previously described by the authors being employed.[4] The location of the measurements taken is illustrated in Fig. 1.

More specifically the groups were derived in the following way:—

1944 Season.

(1) Two groups, each of 100 ewes selected from a line of 600 ewes. These were mated by artificial insemination to a single selected Southdown ram.

1945 Season.

(2) Two groups, each of 75 selected from a line of 1,000 ewes, the two groups being mated to a group of good type Southdown rams. A small proportion of the ewes in each group were the same as employed in the first season.

1947 Season.

(3) Two groups each of 80 ewes selected from a line of 1,400 ewes, a group of selected Southdown rams being used for mating.

It will be noted that the design of the experiment was such that a very much higher intensity of selection was employed than is ever likely to be met with in practice. Thus, in the first year selection in favour of good type ewes involved culling of over 80 per cent of the flock and in the second and third years culling of over 90 per cent. For the same reason the poor type ewes represented equally extreme types. The two types of ewes are illustrated in Figs. 2 and 3. All selections were necessarily subjective and along the same lines as employed by the sheep-farmer. In view of their unreliability no measurements on the live sheep were taken to support the judgments made, but it was found possible to secure post-slaughter carcass measurements on a reasonable sample of the breeding ewes employed. These measurements, summarized in Table I, provide an objective measure of the reality of the conformation differences in the two types of ewe employed.

It will be obvious that if the carcass type of the ewe exerts any material effect upon the carcass type of her lambs, the lambs from the good type groups should show a marked superiority over the lambs from the poor type groups. Results in terms of carcass measurements of all lambs slaughtered fat off the mother are shown in Table II.

Table I. Carcass Measurements of Ewes

Type of Ewe.	No. of Ewes.	Carcass Length. (mm.)	Tibia/Tarsus Length. (mm.)	Cannon Bone. Weight. (g.)	Cannon Bone. Length. (mm.)	Carcass Weight. (lb.
Poor	82	707	217	44·7	127·7	67
Good	84	678	192	35·6	112·9	61

Results

In respect to width of gigots (G), no difference existed in any year between the two groups of lambs. This measurement alone or in combination with others is highly correlated with the composition of the carcass. Essentially it provides an index of the development of the hind-quarters. Wide gigots are desirable from the point of view of conformation so that this measurement has both a qualitative and a quantitative significance.

TABLE II. EFFECT OF TYPE OF EWE ON CARCASS MEASUREMENTS OF LAMBS

Year.	1944.		1945		1947.	
Type of Ewes.	Poor.	Good.	Poor.	Good.	Poor.	Good.
Width of Gigots (G) in mm.	234	(N.S.) 234	220	(N.S.) 221	232	(N.S.) 232
Tibia-Tarsus Length (T) in mm.	173	(N.S.) 172	170	(S.S.) 166	172	(S.S.) 168
Depth of Crutch (F) in mm.	240	(N.S.) 238	236	(S.S.) 230	235	(S.) 231
Cannon Weight in (g.)	32	(N.S.) 31	31	(S.S.) 29	32	(S.S.) 30
Cannon Length in mm.	108	(S.) 106	105	(S.) 102	106	(S.) 103
(T) X (G) index	406	401	374	367	399	391
Carcass Weight in lb.	36	36	32	31	37	36
No. of Lambs	71	73	62	64	93	77
Age in Days	138	146	116	120	—	—

In respect to Tibia-Tarsus length (T), lambs from the good type ewes showed slightly shorter measurement, the differences being insignificant statistically in the first year, but highly significant in the last two years. This measurement is highly correlated with the total bone and muscle of the carcass and in combination with depth of crutch (F) and width of gigots (G) provides an even more efficient index of bone and muscle[4]. While a long T-measurement thus indicates greater total muscle, this is due to length development rather than thickness of muscle. Since the latter is the more important requirement from a quality viewpoint the most desirable conformation in the fat lamb is associated with a short T[4]. On this basis, therefore, the lambs from the good type ewes tended to have less total muscle but slightly better muscular conformation. The differences, however, were small.

The measurement of the depth-of-crutch, in which shortness is desirable, was again slightly less in the case of lambs from the better type ewes. It is important primarily from a qualitative point of view, a short measure indicating a well filled leg with adequate fat cover.[4] A difference of only 2 mm existed in the first year, 6 mm in the second year and 4 mm in the third year, these being significant only in the last two seasons.

The value of the Cannon Bone weight and length in assessing the total weight of bone in the carcass has been well established.[4] From an essentially quantitative point of view, the heavier the weight of this bone the greater the weight of both bone and muscle in the carcass. Cannon length has mainly a qualitative significance indicating general conformation, a short cannon being associated with a desirable blocky type. Ideally, therefore, the lamb should have relatively heavy cannon weight and short cannon length. On this basis, lambs from the poorer quality ewes showed slightly heavier but longer cannons than lambs from the good type ewes.

Fig. 2

Fig. 3

The product of T x G provides one of the most satisfactory indices of total bone and muscle in the carcass[4]. A very small difference was found to exist between the two groups, lambs from the poor ewes showing slightly higher figures.

The all-over picture presented by these results is one indicating a slight superiority in favour of lambs from the good type ewes which were of slightly better conformation, with more fat but with less bone and muscle than lambs from the poor type ewes.

That these differences were reflected to some small degree in grading is indicated in Table III, which sets out the number of Prime Down Cross, Prime Crossbred and Second Grade lambs from each group, as evaluated under the official grading standards of the N.Z. Meat Producers' Board.

Table III. Effect of Type of Ewe on Grading of Lambs

Year.	Grading of lambs from Poor Type Ewes.			Grading of lambs from Good Type Ewes.		
	Prime Down Cross.	Prime Cross Bred.	Second Grade.	Prime Down Cross.	Prime Cross Bred.	Second Grade.
1944	38	24	9	53	17	3
1945	21	27	14	28	31	5
1947	72	20	1	58	19	0
Total No.	131	71	24	139	67	8
Average Per Cent.	58	31	11	66	31	3

It will be noted that lambs from the good type ewes yielded 8 per cent more Prime Down Cross grade, the same percentage of Prime Crossbred Grade and 8 per cent less Second Grade than did lambs from the poorer class ewes. These differences are not statistically significant. This trend was more or less similar in each season although the small numbers involved are inadequate to permit of the statistical significance of "within-season" differences being measured. In the third year where measurement differences were significant and numbers fairly large, the grading difference that existed was in favour of lambs from the poorer type ewes, these grading 77 per cent of Prime Down Cross grade and 22 per cent of Prime Crossbred grade, as against 75 per cent and 25 per cent respectively for lambs from the good type ewes.

Discussion

It is clear from three successive seasons' results over a total population of approximately 3,000 ewes that a very intensive selection potential of approximately 90 per cent for conformation resulted in only a very small difference between progeny groups. This situation might be interpreted as indicating the marked dominance effects of the Southdown breed when mated to a long-wool breed, or, alternatively, since the Southdown has been used on both groups, it could also be argued that the results substantiate the low heritability estimates previously mentioned for carcass conformation in the Romney breed. The differences between progeny groups are quite in keeping with McMahon's heritability co-efficient for Romneys of 13 per cent.[1]

A further possible explanation for the small differences between the two progeny groups might be that the poorer conformation ewes provided more milk than the good type ewes, so that a real superiority in carcass conformation of the lambs from the latter has been masked by a poorer nutritional environment. Though milk yield could not be measured directly in these experiments, the similarity in the growth curves of the two groups makes this explanation unlikely. From the age-for-weight figures reported above (Table II), the growth rate differences that existed were in favour of the progeny of the poorer type ewes. These, however, were of very small magnitude, amounting to an increased gain per day in the first two years of only 0.01 lb to 0.02 lb. Any real difference in milk yield could express itself in terms of carcass conformation only if it were responsible for differences of considerable magnitude in the rate of growth of the lambs concerned.[5]

From a commercial point of view, the grading results indicate very little difference between the two groups over the three years. Indeed, in view of the price differential of approximately 5/- per head normally existing between ewes of the two types employed, the 8 per cent fewer Prime Down Cross grade and more Second grade lambs amongst the progeny of the poorer type ewes is not nearly large enough to compensate for the higher ewe cost. The difference in value between Down Grade and Second Grade lambs normally averages approximately 1d. per lb, or 3/- per lamb on lambs of the weight involved in this experiment. The increased return of 3/- per lamb over only eight per cent of the flock does not nearly meet the extra cost of 5/- per ewe over the whole flock.

At least it can be said that in the commercial production of fat lambs there is no material advantage in selecting ewes for carcass conformation to the degree normally applicable in practice, or, alternatively, where ewes are purchased for fat lamb production it is unlikely that a higher price paid for better conformation will result in greater net returns.

Acknowledgments

Thanks of the authors are due to Mr. S. Southcombe for assistance in inseminating ewes in the first season; and to the Horotiu Freezing Works for facilities in examining carcasses on the hooks.

References

[1] McMahon, P. R. (1943): *Proc. N.Z. Soc. Animal Prod., 3,* 70-81.
[2] Hazel, L. N. and Terrill, C. E. (1946): *J. Animal Sci., 5,* 55-61.
[3] Rae, A. L. (1948): *Proc. N.Z. Soc. Animal Prod., 8,* 97-104.
[4] Walker, D. E. and McMeekan, C. P. (1944): *N.Z. J. Sci. Tech., A, 26,* 31-73.
[5] Wallace, L. R. (1948): *J. Agric. Sci., 38,* 93-153, 243-302, 367-401.

MAGNESIUM DEFICIENCY IN TOMATO LEAVES

By J. K. JOHANNESSON, Soil Bureau, Department of Scientific and Industrial Research

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Summary

(1) A chlorosis of the leaves of glasshouse tomatoes of Potentate variety in the Hutt Valley has been related to a low level of magnesium in the leaves.

(2) The soils are of normal exchangeable magnesium content, high base saturation, and fertilized heavily with potash and phosphate.

(3) Analytical data are presented for the distribution of CaO, MgO and K_2O in the plant and leaves; as little as 0.06 per cent MgO has been found in chlorotic tissue.

(4) An inverse relationship is shown between MgO and K_2O in the affected leaves, and a direct relationship between MgO and CaO.

INTRODUCTION

LATE in 1944 a tomato grower in the Hutt Valley reported that his yield of Potentate tomatoes was falling, that his fruit, although well flavoured, were tough-skinned and hard, and that the stalks of his bushes were hard and brittle. He had been using each year increasing quantities of potash salts, and the problem he set was whether there was a nutritional unbalance due to high potash dressings.

On inspection there was evident in the plants all the characteristics described by the grower, but, in addition, the bottom leaves of some plants showed symptoms very similar to those illustrated by Wallace[1] for magnesium deficiency in tomatoes, while the fruit had a "greenback" similar to that recorded by the same author for this deficiency[2]. In view of the known relationship between high potash and low magnesium of plants[3], it was decided to investigate the soils and the affected leaves for magnesium deficiency.

SUMMARY OF PREVIOUS FERTILISER PRACTICE

The soil, Hutt silt loam, had not been sterilized nor had it been changed in the glasshouse. Each year the grower had bought in baled straw, allowed it to rot in the open and dug it in during the following year at the rate of 80 bales per 500 sq. yd. In an endeavour to combat disease in his glasshouse he had, since 1939, used increasing quantities of potash. In 1944 his basal dressing was at the rate per plant of 0.75 oz. K, 0.26 oz. N, and 0.83 oz. P_2O_5 followed by much smaller topdressings through the growing season. The fertilizers were applied in the following forms:—

K: Mainly potassium sulphate with a small amount of chloride.

N: Dried Blood, fish manure for basal; blood, ammonium sulphate, sodium nitrate for topdressings.

P_2O_5: Bone dust, fish manure for basal; super phosphate for topdressings.

TABLE I. SOIL ANALYSES OF THE AFFECTED SOIL : HUTT SILT LOAM

Lab. No.	Depth.	pH.	Soluble in 1 per cent. citric acid. P_2O_5 per cent.	Organic C. per cent.	Total N. per cent.	C. — N.	Base Exchange. Exchange capacity. m.e. per cent.	Total bases. m.e. per cent.	Base Satn. per cent.	Ca. m.e. per cent.	Mg. m.e. per cent.	K. m.e. per cent.	Description.
3897A	0–3	6·5	0·44	3·5	0·32	11	21·1	23·0	(100)	19·5	1·55	1·95	Sth end, House 5
3897B	3–6	6·7	0·43	3·3	0·29	11	19·9	21·4	(100)	18·1	1·45	1·90	Soil dry
3897C	6–12	6·2					18·8	18·2	93	15·6	1·05	1·60	Chlorosis severe
3898A	0–3	5·1	0·44	3·7	0·37	10	21·5	17	79	14·5	1·15	1·40	Near Sth end of House 5
3898B	3–6	5·2	0·41	3·5	0·34	10	21·1	17·2	81	14·3	1·20	1·70	Soil moist
3898C	6–12	5·8					18·5	15·2	82	12·5	1·05	1·65	Chlorosis severe
3899A	0–3	5·2	0·42	3·7	0·36	10	21·0	17·6	84	14·9	1·45	1·25	10th row from Nth end, House 5
3899B	3–6	5·3	0·36	3·3	0·29	11	20·2	15·7	78	13·0	1·30	1·40	Soil moist
3899C	6–12	5·7					18·8	14·6	77	12·0	1·15	1·40	Chlorosis moderate
3951A	0–3	6·0	0·14	3·5	0·28	12	16·4	10·35	63	7·1	1·50	1·75	Under hedge near N.E. corner
3951B	3–6	5·9	0·13	2·3	0·22	10	14·9	8·7	58	6·7	0·95	1·05	Sample representative of more
3951C	6–12	5·8	0·07	2·1	0·21	10	14·2	7·9	56	6·2	0·65	1·05	nearly normal soil
3936A	0–6	5·9	0·35	2·5	0·24	10	17·2	13·3	77	10·0	1·00	1·30	Near glasshouse in
3936B	6–12	5·8	0·20	1·9	0·21	9	15·2	9·5	63	8·2	0·70	0·55	outside tomato area

Analyses on air dry soil corrected to oven dry basis.

Analyses by W. B. Healy and L. B. Blakemore.

SOIL ANALYSES

Soil samples were collected both inside and outside the glasshouse, and in Table I are set out some typical analyses.

From Table I it will be seen that the glasshouse soils are well saturated with bases, rather more so than the soils outside the houses. Phosphates are abnormally high. The general level of phosphates is high throughout the Hutt Valley, but it is evident that a further build up has occurred under the high basal dressings. Humus has been maintained by the digging in of rotted straw. The exchangeable base figures would not at first sight suggest a magnesium deficiency such as has been associated with soil figures of 0.3 m.e. per cent in apple orchards[4]. By comparison with the soils outside the glasshouse the potash figures are high. This would suggest that the topdressing has penetrated at least to a depth of 12 in. The outside soils have high potash figures, in keeping with the general range of Hutt Valley soils wherein exchangeable potash ranges from 0.5 to 2.0 m.e. per cent.

On the present figures there has been an increase of potash in the soil, but perhaps hardly sufficient to suggest a potash induced magnesium deficiency when the exchangeable magnesium figures appear adequate. Nevertheless, the data of Prince *et al.*[5] suggest that soils in which the exchangeable Mg is less than 6 per cent of the total bases are likely to respond, where lucerne is grown, to applications of magnesium. The Hutt soils in which the chlorosis is severe approach this figure.

PLANT ANALYSES

To check up on the magnesium level in the plant, some preliminary analyses were done, and it was found that chlorotic leaves contained 0.3 per cent MgO, and green leaves in the same house 0.5 per cent MgO. According to Walsh and Clarke[3] the threshold for Mg deficiency is 0.2 - 0.3 per cent MgO, and a comparison with these results suggested that the diagnosis of magnesium deficiency should not be lightly discarded even in the face of unpromising soil evidence.

FIG 1

FIG. 2

The findings of other investigators have shown that the distribution of elements deficient in the plant follows a definite pattern, as illustrated by the fact that Kidson at Cawthron Institute found that the magnesium content in magnesium deficient apple-trees was greatest in the newest leaves and lowest in the old[6].

Considering the above facts it was decided to take two series of samples: Series A, to follow the distribution of certain elements throughout the plant, and Series B, to examine the relation of elements in leaves of different degrees of chlorosis, ranging from almost colourless to dark green.

Series A:

A leaf of the tomato plant has two pairs of large leaflets with three large leaflets at the tip, with some small ones in between. Starting from the inside, the first pair was called A, the second pair B, and the tip leaflets C. Fig. 1.

Six plants were selected at random (this meant that some were green and others chlorotic) in an affected greenhouse. At the time of sampling these plants had 38-40 leaves of which the lower 7-8 had been cut off. From each plant the 10th, 15th, 20th, 25th, 30th and 36th leaf was removed as a sample. The correspondingly numbered leaves were combined giving six samples, each containing six leaves, all of the same physiological age. Each of these samples had the A, B, and C groups of leaflets separated according to the system explained above, giving a total of eighteen samples.

Each of these samples was analysed for its MgO, CaO and K_2O contents, which are shown in Table II.

TABLE II. ANALYSIS OF SAMPLES OF TOMATO LEAVES
(Series A)

No. of leaf.	Position.	MgO. Per cent.	CaO. Per cent.	K_2O. Per cent.
10	A	0·74	12·0	3·1
	B	0·58	12·8	2·8
	C	0·50	11·8	2·6
15	A	0·54	11·2	2·4
	B	0·59	10·3	3·5
	C	0·43	10·2	3·5
20	A	0·22	7·7	3·5
	B	0·27	7·8	3·9
	C	0·16	7·0	3·6
25	A	0·29	6·5	2·8
	B	0·25	5·5	3·5
	C	0·22	4·7	3·9
30	A	0·33	6·0	2·4
	B	0·29	5·0	2·6
	C	0·26	4·3	2·8
36	A	0·40	5·1	2·4
	B	0·36	3·6	2·6
	C	0·40	0·2	2·8

All analyses on a dry weight basis.

The data show that the magnesium content of the leaves is higher at the base of the plant and at the top than it is in the middle. There is little significant difference between leaflets on the same shoot, but, in general, the outermost leaflets are higher than the innermost. Lime content decreases steadily from the older shoots to the younger. In general, the tip leaflets are lower in lime than those nearest the main stalk. Potash does not vary in any regular pattern but there is a tendency for potash to be higher in the tip leaflets in the middle of the plant where magnesium is lower.

These analyses have not confirmed a distribution of magnesium that could be related to the onset of the chlorosis showing first on the older leaves. In the old leaves the Ca/Mg ratio may be of greater significance than the K/Mg ratio. Since many of the analyses for magnesia were near the deficiency level it was decided to follow out the pattern of chlorosis on selected bushes.

Series B:

From the same greenhouse as Series A, a large number of leaves of the same physiological age, e.g., 17 - 20th shoots, were taken and sorted into five groups, representing extremely chlorotic, very chlorotic, moderately chlorotic, slightly chlorotic and green. Fig. 3 illustrates the range of chlorosis found in the glasshouse. The samples representing two extremes and the middle condition were each divided into two portions. One portion was kept intact, and the other portion had each leaf cut in such a way that the outer portion (the more chlorotic) was separated from the mid rib and adjacent leaf material. Fig. 2. Thus, each of the above three samples was further subdivided into three portions. The analysis of these samples is given in Table III.

TABLE III. ANALYSIS OF LEAVES OF VARYING DEGREES OF CHLOROSIS

Leaf Condition.	Portion of leaf.	MgO. Per cent.	CaO. Per cent.	K_2O. Per cent.
Extreme chlorosis	whole	0·10	4·7	4·6
	outer	0·06	3·8	3·9
	inner	0·25	6·0	5·0
Marked chlorosis	whole	0·26	5·3	5·0
Moderate chlorosis	whole	0·23	5·7	4·8
	outer	0·21	5·6	2·6
	inner	0·30	6·5	4·8
Slight chlorosis	whole	0·49	5·9	3·8
Green	whole	0·49	7·1	3·3
	outer	0·43	6·2	3·0
	inner	0·56	7·5	3·3

Note.—All analyses on a dry weight basis.

The results of Table III show conclusively that there is a good correlation between the deficiency of magnesium and the degree of chlorosis, and, further, that there is a definite inverse relationship between the magnesium and potassium contents, while MgO and CaO follow similar paths. This latter correlation makes it difficult to press the point that the Ca/Mg relationship is significant. The relatively high MgO content of the midrib as compared with the outer tissue in the case of the extreme chlorosis should be noted.

FIG. 3.

DISCUSSION

The data presented above show a low content of magnesium in the affected leaves and a good correlation between degree of chlorosis and magnesium deficiency in the leaves. Magnesium is not low in the soil, and the possibility of a potash induced magnesium deficiency has been investigated. The K_2O/MgO ratio is highest in the chlorotic leaves and lowest in the green, but on the soil and plant analyses, however, there does not appear to be sufficient evidence to support this theory. Admittedly, potash is high in the soil, and possibly during the early part of the growing season high soluble potash is an important factor in growth, but potash is not unreasonably high in the leaves examined, and it is not yet clear what effect potash levels such as these could have on what is quite a normal exchangeable magnesium content in the soil.

The high lime content of the leaves is worthy of comment, but CaO varies with magnesium, and while there is a wider CaO/MgO ratio for the most chlorotic leaves the ratio does not vary markedly for the remainder.

Experiments by the Biotics Division of this Bureau were in train to elucidate some of these points, but changes in glasshouse management and a lack of suitable experimental material have delayed the investigation. To aid other investigations the present data are recorded as an indication that a chlorosis in glasshouse tomato leaves is associated with a deficiency of magnesium in the chlorotic areas of the leaves, but no claim is made as to how the deficiency arises, or whether the deficiency is the primary cause of the chlorosis or a symptom of some other nutritional unbalance.

ACKNOWLEDGMENTS

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REFERENCES

(1) WALLACE, T. (1943): The Diagnosis of Mineral Deficiencies in Plants. London. H.M. Stationery Office; pp. 75, 76.

(2) —— (1944): Supplement to the above; p. 22.

(3) WALSH, T. and CLARKE, E. J. (1945): *Proc. Royal Irish Acad., B, 50,* 245-63.

(4) KIDSON, E. B., ASKEW, H. O. and CHITTENDEN, E. (1940): *N.Z. J. Sci. Tech., 21,* 305A-18A.

(5) PRINCE, A. L., ZIMMERMAN, M., and BEAR, F. E. (1947): *Soil Sci., 63,* 69-78.

(6) KIDSON, E. B. (1946): *N.Z. J. Sci. Tech., A, 28,* 173-82.

EFFECT OF MOISTURE CONTENT ON THE VIABILITY OF ITALIAN RYEGRASS SEED IN STORAGE

By L. W. GORMAN, Grasslands Division, and R. M. GREENWOOD, Plant Chemistry Laboratory, Department of Scientific and Industrial Research, Palmerston North

(*Received for publication, 27 May 1950*)

Summary

Samples of Italian ryegrass were stored at room temperatures for four years in atmospheres of low and high humidities.

It was found that seed held at 16 per cent and 19 per cent moisture deteriorated rapidly; that with seed at 13 per cent moisture, germinating capacity remained high for two years but then declined rapidly; that seed at 11 per cent or less moisture retained its initial high germinating capacity throughout the trial period of four years. Air dried seed stored at room temperature was found to contain 12 per cent of moisture.

INTRODUCTION

Moisture content and temperature are of first importance in the storage of seed but in districts which experience showery weather at harvest time some crops may have to be taken into storage at relatively high moisture contents. Under these conditions crops of grass seed are most difficult to handle, and unsatisfactory storage of the seed has been known to cause a rapid loss of viability. The actual effects of moisture content on ryegrass seed in storage have not been fully investigated. Gane[1] found that the water content of grass and other small seeds fluctuated with the humidity of the surrounding atmosphere, but in sealed containers, with thinly spread seed exposed to atmospheres of controlled humidity, there was an exchange of water until equilibrium was reached within the comparatively short time of 2-7 days. Similarly the uptake of water and its penetration into a 4-in. column of grass seed (Chewing's fescue) was very rapid in an atmosphere of high relative humidity (85 per cent) at a temperature of 15°C. (59° F.).

Even under average commercial conditions some vegetable seeds have shown a marked loss of viability on storage[2], and have become useless within 1-2 years. Similarly the loss of viability of Chewing's fescue seed has been a serious problem to the producers of this grass seed in New Zealand, and to the seed trade in the United Kingdom. From his investigations of this problem Foy[3] has shown that fescue seed with a high moisture content (20 per cent) held at 30° C. deteriorated rapidly after 10-14 days, and even more rapidly at 40° and 50°C. Seeds with a water content of 13 per cent deteriorated more slowly, but it was not until the water content was reduced to, and maintained at, 5 per cent that seeds retained their viability at 30°, 40° or 50° C. for forty-two days. Even at room temperature (16-20°C.), the loss of viability occurred after 4-5 months at 20 per cent water content, and after 8-9 months at 13 per cent, but at 5 per cent water content there was no loss. Hyde[4] examined the effect of heating fescue seeds to 50°, 60°, 70°, 80°, and 90° C. in order to determine the maximum temperatures and periods of time for

the safe drying of fescue seed of high and low moisture content. In the United Kingdom Lewis[5] also found that, in some seasons, there was a marked loss of viability in stored fescue seed. More recently Gane[6] has followed changes in viability of fescue seed held for long periods at temperatures of 0°, 15° and 30°C. and relative humidities of 45, 60, 70 and 80 per cent, as well as in atmospheres of air, nitrogen, and nitrogen containing about 1 per cent of oxygen. He found that the rates of deterioration were reduced by lowering the temperature of storage and by reducing the water content of the seeds, rather than by reducing or excluding oxygen.

The experiments reported below were commenced in order to determine changes in viability of Italian ryegrass seed when held, for long periods, under such conditions of humidity and moisture content as might occur naturally while in storage.

EXPERIMENTAL METHOD

New season's seed from the 1944-45 harvest of an Italian ryegrass (*Lolium multiflorum*) selection was used. Methods of maintaining constant relative humidities in closed containers have been reviewed by Buxton[7]. As it was necessary to maintain samples of seed at definite moisture contents, and yet be able to remove subsamples periodically, it was decided that a suitable method was to store the samples, over sulphuric acid solution, in desiccators.

Preliminary experiments were conducted to determine the concentrations of sulphuric acid required to give a suitable range of moisture contents. The final solutions were made up in August 1945, and 500 ml. put in each desiccator together with 35 g. of seed. The desiccators were well sealed and placed in a cupboard. They were opened at three or six monthly intervals for the removal of subsamples for moisture determination, and for germination tests. The mean storage temperature was 55° F. with a possible maximum variation from 40° to 70° F. The seed as harvested contained 32.7 per cent of moisture but this had been reduced by air-drying to 14.4 per cent before the experiment was started. The germinating capacity was 96 per cent of viable seeds.

In the desiccators all the seed samples, except the one at the lowest moisture content, came to equilibrium moisture content within three weeks. The lowest one took rather longer, but the stage was soon reached when each was within 1 per cent of the desired figure, and throughout the experimental period of four years variation in moisture content in each desiccator was within a range of 1 per cent. The concentrations of acid, corresponding relative humidities, and resulting moisture contents obtained in the seed are given in Table I.

TABLE I.

Concentration of H_2SO_4 (S.G. 1·84). (ml. per litre.)	Relative Humidity.	Seed moisture percentage.
388	35	8·7
303	53	11·2
227	70	13·4
160	83	16·1
117	89	19·0

At the completion of each three-monthly period in the first three years, and at six-monthly intervals in the fourth year, seed samples for a germination test were drawn from each of the desiccators. These tests were made according to international standards, and with a known high germinating line of seed included as a control.

RESULTS

The effects of the various treatments are shown graphically (Fig. 1). The germination counts at the three-monthly intervals have given a series of distinct lines and curves. Except for some variation, due to sampling, the graphs for Treatments 1 and 2 (approximately 9 and 11 per cent moisture) are practically horizontal, i.e. these samples show little loss in germination at the end of the four-year period. Under Treatment 3 (13 per cent moisture) the loss in germination became apparent after a two-year period, and a steady decline then followed. At 16 per cent moisture (Treatment 4) deterioration commenced within the first six months, and the germination was reduced steadily, until there was complete loss of viability at the end of three years. A moisture content of 19 per cent (Treatment 5) had the effect of causing immediate damage to the stored seed, and this was so severe that within twelve months ninety per cent of these seeds failed to germinate, and the remaining ten per cent became lifeless within a further period of six months.

DISCUSSION

Although seed stored in bags gradually adjusts its moisture content to the normal "air dry" moisture content, the questions have often arisen as to "How wet can seed be bagged for storage without inducing a rapid loss of vitality?" and "For how long will 'air dry' seed retain its initial germination?"

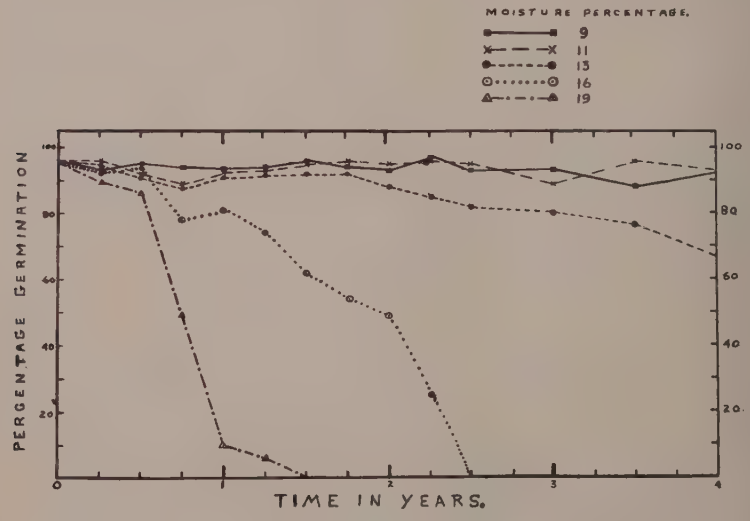

FIG. 1.—Graph showing the viability of Italian ryegrass seed of different moisture contents, at three-monthly intervals, over a four-year period.

After having determined that samples from four different lots of ryegrass seed which had been air dried and stored for twelve months, tested 12.1, 11.8, 11.1, and 11.8 per cent of moisture respectively, and with the data from the experiments detailed above it was possible to answer these questions, and draw definite conclusions regarding the storing of Italian ryegrass seed. Probably these results would apply also to harvestings of short rotation ryegrass and true perennial ryegrass.

CONCLUSIONS

From an inspection of the graph (Fig. 1) the following conclusions may be drawn:—

(1) The storing of Italian ryegrass seed, with a moisture content of 16 per cent and higher, would result in a rapid loss of viability likely to end in a complete loss of germination within twelve months.

(2) Air drying and storage at 13 per cent moisture content would be satisfactory for a period of up to two years.

(3) If the seed had to be kept for longer than two years then a reduction to 11 per cent moisture would be necessary. This would necessitate mechanical drying and storing in some form of sealed container.

Hence, for practical purposes once the seed has been brought uniformly to an "air dry" figure (approximately 12 per cent moisture) it could safely be stored, and it should retain its initial germination for a period of not less than two years.

REFERENCES

(1) GANE, R. (1948): The water content of the seeds of peas, soya beans, linseed, grass, onion and carrot as a function of temperature and humidity of the atmosphere. *J. Agric. Sci., 38,* 81-3.

(2) —— (1948): The effect of temperature, water content and composition of the atmosphere on the viability of carrot, onion and parsnip seeds in storage. *Ibid., 38,* 84-9.

(3) FOY, N. R. (1934): Deterioration problems in New Zealand Chewing's fescue. *N.Z. J. Agric., 49,* 10-24.

(4) HYDE, E. O. C. (1935): Chewing's fescue seed. The influence of temperature and moisture content upon the rate of loss of its germinating capacity. *Ibid., 51,* 40-2.

(5) LEWIS, I. G. (1934): Chewing's fescue. The problems of germination and purity and their influence on green-keeping and commerce in the United Kingdom. *Ibid., 49,* 6-9.

(6) GANE, R. (1948): The effect of Temperature, humidity and atmosphere on the viability of Chewing's fescue grass seed in storage. *J. Agric. Sci., 38,* 90-2.

(7) BUXTON, P. A. (1931): The measurement and control of atmospheric humidity in relation to entomological experiments. *Ent. Res. Bull. 22,* 431-47.

RESISTANCE OF LINSEED AND LINEN-FLAX VARIETIES TO FLAX RUST (*Melampsora lini*) IN NEW ZEALAND PART II

By I. A. M. Cruickshank, Plant Diseases Division, Department of Scientific and Industrial Research, Christchurch

(*Received for publication, 25 October 1949*)

Summary

1. The results of a disease survey during the 1948-49 season confirmed the rust-resistance of varieties of linseed which showed high resistance in glasshouse trials.

2. Twenty-one linseed varieties and one linen-flax variety were tested in the glasshouse for resistance to flax rust. Of these, five linseed varieties were found to be highly resistant, while sixteen other linseed varieties and one linen-flax variety showed varying degrees of susceptibility to the disease.

3. The high resistance of one previously tested variety of linseed and six previously tested varieties of linen flax was confirmed.

4. Two species which grow wild in parts of New Zealand, viz. *Linum monogynum* and *L. marginale*, were shown to be susceptible to flax rust from *L. usitatissimum*.

Introduction

A disease survey was carried out during the 1948-49 season to assess the field resistance of linseed and linen-flax (*Linum usitatissimum*, Linn.) varieties which showed high resistance to flax rust (*Melampsora lini* (Ehrenb.) Lev.) in glasshouse trials (Cruickshank, 1950). Linseed-growing areas in Canterbury, Otago, and Southland were visited, flax rust being found in each of the districts. Crops of the variety Punjab were severely damaged by rust while those of Golden Viking were only slightly infected. Although the latter variety showed more rust than in previous seasons it was still resistant. Sheyenne, another variety which showed high resistance in glasshouse trials (Cruickshank, *loc. cit.*), was grown for the first time commercially in New Zealand. Small acreages were sown throughout the linseed-growing areas and they remained completely free from rust. The linen-flax varieties Stakhanovetz, D-83, and 806/3, were highly resistant to rust in trial areas in the linen-flax-growing districts.

Experimental Method

Collections of uredosori from representative areas of linseed and linen-flax-growing districts were made in the course of the field survey mentioned above. These collections were bulked, inoculations made, and the relative resistance of varieties determined by the methods described in a previous paper (Cruickshank, *loc. cit.*).

Twenty-two varieties new to this country were tested, and, in addition, the linseed variety Sheyenne (C.I. 1073) and the linen-flax varieties Stakhanovetz, D-83, 806/3, Wada, Cascade, and Argentine II were re-tested. The linen-flax varieties just mentioned were tested in one trial only, using approximately 200 plants of each. The indigenous and

Australian species of flax, *L. monogynum* Forst. f and *L. marginale* A. Cunn., respectively, were included in this trial. As infection of both these species was uniformly severe, no uredosorus counts were made. The varieties were tested in three groups and the results are shown in Table I.

TABLE I. VARIETAL SUSCEPTIBILITY OF LINSEED AND LINEN FLAX TO FLAX-RUST

Variety	C.I.No.*	No.of Trials	Variety Grand ** Mean of uredosorus Counts per pot of ten plants	General Grading
First Series				
Ottawa 770B	355	3	0	Highly resistant
Argentine Selection	462	3	13	
Argentine	705-1	3	182	Susceptible
J.W.S.	708-1	3	240	
Kenya	709-1	3	241	
Very pale blue crimped	647-1	3	465	
Bombay	42	3	516	
Abyssinian	701	3	549	
Williston Brown	803-1	3	835	
Buda	270-1	3	933	
Akmolinska	515-1	3	959	
Williston Golden	25-1	3	1081	
Second Series				
Sheyenne	1073	3	0	Highly resistant
B5128		3	1	
Tammes Pale Blue	333-1	3	2	
Marye	112	3	3	
Rocket		3	48	Susceptible
Liral Dominion		3	318	
Leona	836	3	444	
Arrow		3	545	
Bolley Golden	644	3	590	
Newland	188	3	659	
Dakota		3	677	
Third Series				
Stakhanovetz		1	0	Highly resistant
D-83		1	0	
806/3		1	0	
Wada		1	0	
Cascade		1	0	
Argentine II		1	0	
L. monogynum		1	Severe infection	Susceptible
L. marginale		1	Severe infection	

* C.I. No. refers to accession number of the Division of Cereal Crops and Diseases, Department of Agriculture, United States of America.

** For First Series difference required for Significance at 1% level = 101.0
For Second Series " " " 1% level = 30.0

DISCUSSION AND CONCLUSIONS

Since each group of varieties shown in Table I was tested at a different time, direct comparison between varieties is valid only within the groups. However, since the sources of inoculum and the techniques involved were the same for each trial, approximate comparison between groups is reasonable.

Linseed varieties:

Of the 21 new varieties tested, Ottawa 770B (C.I. 355), Argentine Selection (C.I. 462), B.5128, Tammes Pale Blue (C.I. 333-1), and Morye (C.I. 112), were found to be highly resistant. The high resistance of Sheyenne (C.I. 1073) was confirmed.

The remaining sixteen varieties, viz. Argentine Selection (C.I. 705-1), J.W.S. (C.I. 708-1), Kenya (C.I. 709-1), Very pale blue crimped (C.I. 647-1), Bombay (C.I. 42), Abyssinian (C.I. 701), Williston Brown (C.I. 803-1), Buda (C.I. 270-1), Akmolinsk (C.I. 515-1), Williston Golden (C.I. 25-1), Rocket, Leona (C.I. 836), Arrow, Bolley Golden (C.I. 644), Newland (C.I. 188), and Dakota, showed varying degrees of susceptibility to the disease.

Linen-flax varieties:

Only one new linen-flax variety was included in the trials, namely Liral Dominion. This variety proved susceptible to rust. The high resistance of Stakhanovetz, D-83, 806-3, Cascade, Wada, and Argentine II was confirmed.

Other species:

The two species *L. monogynum* and *L. marginale* proved susceptible to flax rust collected from *L. usitatissimum*. *L. monogynum* grows chiefly on rocky places along the coast-line but may be found inland. *L. marginale* is common along roadsides and other waste land in the vicinity of commercial crops of linseed and linen-flax. Both species have in the course of field surveys been observed to be infected with flax rust. They must therefore be considered a serious source of overwintering material from which uredospores of *M. lini* may spread to adjacent linseed or linen-flax crops.

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REFERENCES

CRUICKSHANK, I. A. M.: *N.Z. J. Sci. Tech. A, 31*(6).

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